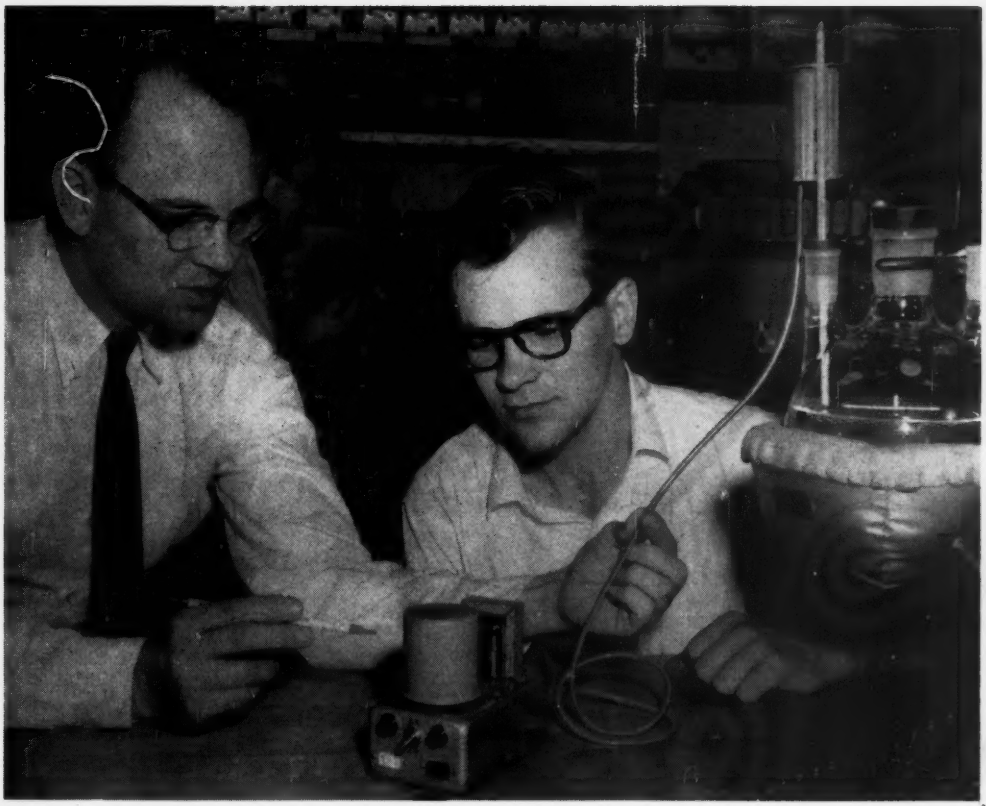
January, 1958

LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

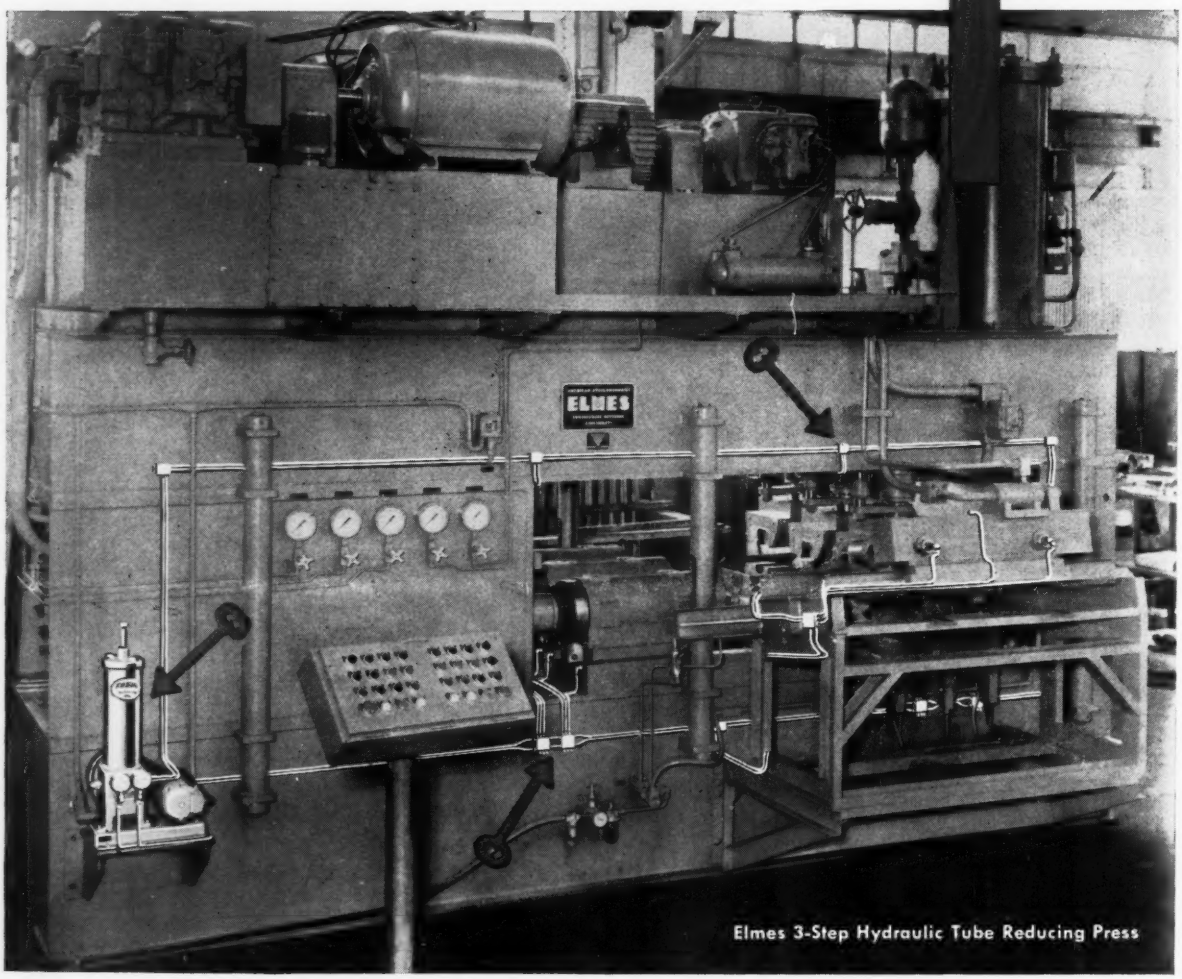


Robot Chemists? See p. 7

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Never a holdup or slowdown to lubricate this tube reducer in Michigan auto factory

FARVAL—
Studies in Centralized Lubrication
No. 203



Elmes 3-Step Hydraulic Tube Reducing Press

● With automation, centralized lubrication is a must. What automated line can afford to slow down or shut down because a forgotten bearing has run dry?

Equipped with Farval, any machine can operate continuously, day and night, with never a pause for lubrication nor a shutdown for a burned-out bearing.

Farval delivers a measured amount of clean oil or grease to every bearing served, at any desired, predetermined interval. No bearing is ever missed—and the amount of lubricant delivered to any one bearing can be varied without affecting the rest of the system. Guesswork and hit-and-miss hand oiling are eliminated with Farval.

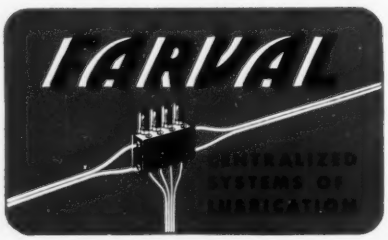
A Farval Centralized Lubrication System, manual or automatic, is easily designed into any machine. Let us send a representative to discuss application of Farval to your equipment. Drop us a line. Also ask for Bulletin 26-S. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm and Gear Company, Industrial Worm Gearing.
In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION—

Wherever you see the sign of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated.

This *Farvalized* machine is an Elmes 60-ton Tube Reducer. In three steps it reduces tubing for drive shafts for a well-known Michigan-made automobile.



LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 14, No.1

January, 1958

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LUBRICATION ENGINEERING is published monthly by the American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Illinois. Current volume single copies 75c. Copies of issues from previous volumes $1.00, if available; Copies to Foreign addresses add 50c per copy. Annual Subscription $6.00 in the USA and Canada, $7.00 to all other countries.

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In our 50 years of manufacturing dispersions of colloidal graphite, we've seen the unique anti-friction properties of this basic material make lubricating problems disappear as if by "black magic". As an additive to lubricating oils and greases, as a parting agent in many kinds of casting and as a dry-film lubricant in diverse fields of metal working . . . in application after application . . . it has proved literally more valuable than gold.

Dr. Edward Goodrich Acheson's invention of colloidal graphite over 50 years ago has been followed by a constantly expanding program of fundamental research and product development. Today, with over 50 different dispersions already in use, three laboratory groups at Acheson are pressing toward perfection of whole new families of dispersions and their applications.

The custom dispersing of solids requires specialized facilities and production techniques. Why not take advantage of Acheson's 50 years of leadership in this field?

You will be interested in the number of different dispersed solids, in addition to graphite, that are being used successfully today in industry. Our Products List gives you, in quick-reading chart form, a résumé of Acheson 'dag'® brand dispersions and their typical applications. Send for your copy. Address Department LE-18.

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Personals

Howard E. Nehms has been appointed general sales manager of the Industrial Chemicals Division of American Cyanamid Company.

Gerald C. Saltarelli has been elected to the newly created position of senior vice president of Houdaille Industries, Inc. Formerly vice president in charge of operations, Mr. Saltarelli will now have administrative responsibility for all Houdaille manufacturing plants and units.

Four persons have been added to Kelite Corporation's research and development laboratories in Los Angeles. New appointees are Morton Schwartz, senior electrochemist; Fred Larsen, physical chemist; Bruce Davis, inorganic chemist; and Ronald North, senior analytical chemist.

Nylok-Detroit Corp., manufacturers of self-sealing, locking and adjusting threaded parts, have completed a facilities expansion program which includes occupation of new office headquarters in the Jaikins Building in Birmingham, Michigan and acquisition of a new manufacturing plant in Troy, Mich.

The appointment of K. H. Rowland as vice-president in charge of production of Union Carbide Chemicals Co., division of Union Carbide Corp., has been announced.

Arthur T. Olsson, assistant sales manager since 1954, has been named sales manager of Acheson Colloids Co. of Port Huron, Mich., manufacturer of colloidal dispersions. Also at Acheson, Alden Crankshaw has retired after 25 years with the company as sales representative and sales manager. Richard G. Hartnett has been named to assist the new sales manager in the home office as assistant sales manager for field activities.

Elco Lubricant Corp. of Cleveland has announced election of D. R. Barber as president and general manager. The new executive has had varied selling and administrative experience in the chemical and electronics fields.

Franchisement of Ritter Engineering Co., Jackson Division, in Chicago as a distributor of Parker hydraulic accumulators and check valves, and Parker synthetic rubber o-rings for sealing application is announced by D. A. Cameron, general sales manager of Parker-Hannifin Corporation, Cleveland.

James F. Allen has been appointed manager of the refinery chemicals department of American Cyanamid Company's Industrial Chemicals Division.

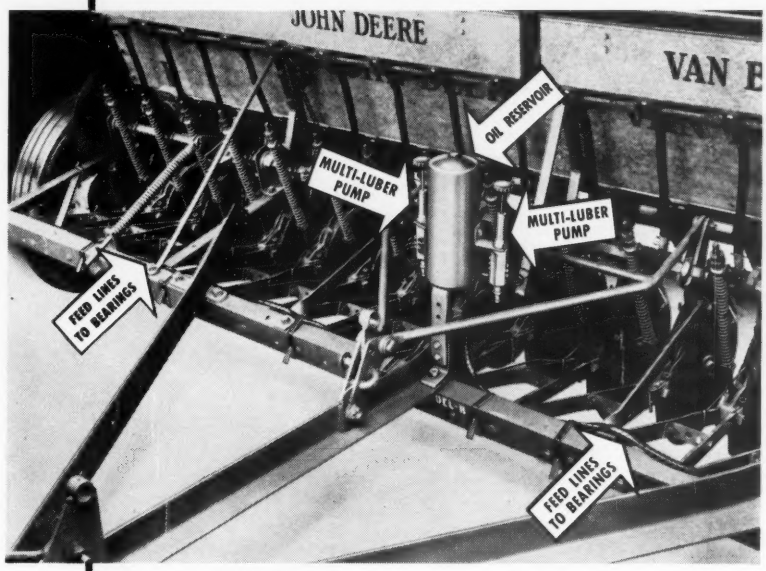
John T. Castles has been appointed sales manager for the Silicone Products Department of the General Electric Company. Formerly manager of rubber market development, Mr. Castles succeeds Jerome T. Coe who has become the department's marketing manager.

Lincoln Multi-Luber*

POWER LUBRICATION SYSTEMS

End lubrication down-time

Extend bearing life



Disk bearing life for John Deere Van Brunt Company Grain Drills is infinitely prolonged through metered positive pressure lubrication to each bearing. Lincoln Multi-Luber* Systems save labor by eliminating need for individual lubrication of furrow openers . . . save time and trouble by using same oil as used in the tractor crankcase.

Versatile Lincoln Multi-Luber Power Lubrication Systems increase machine efficiency in the field . . . on the road . . . in the plant. Pay for themselves in lower operating costs, longer machine life, and more production per daylight hour.

This tested, low-cost method of lubricant application permits simultaneous lubrication of all bearings in seconds . . . on farm implements, or on any machinery or equipment having multiple bearing points. Provides proper amount of lubricant, under pressure . . . flushes bearings as it lubricates . . . extends bearing life and eliminates costly lubrication down-time. Easy to use . . . simple to install . . . precision-built to last.

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Lincoln

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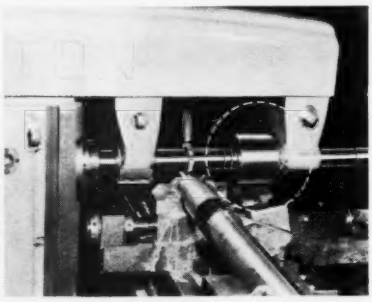
LINCOLN ENGINEERING COMPANY
Division of The McNeil Machine & Engineering Co.
5743 Natural Bridge Ave. • St. Louis 20, Mo.

New Products

NEW UNIT HELPS SOLVE MILLING MACHINE PROBLEMS

A "packaged" unit has been designed to replace bronze bushing in outer support of horizontal milling machines without special



machining or installation. The new support unit is said to eliminate the problem of constant bushing wear and maintenance and to hold precision indefinitely at greatly increased speeds and feeds to take full advantage of carbide cutters. In addition, the new support units reportedly increase cutter life and eliminate cutter breakage, twisted arbors, frozen bushings and chatter. Running at low temperatures, these units eliminate tolerance requirements for heat expansion. "Packaged" outer support units are available for extended or built-in type applications in standard sizes to fit many milling machines and can be obtained from Donley Products, Inc., 11106 Avon Ave., Cleveland 5, Ohio.

IMPROVED REFRIGERATION OIL

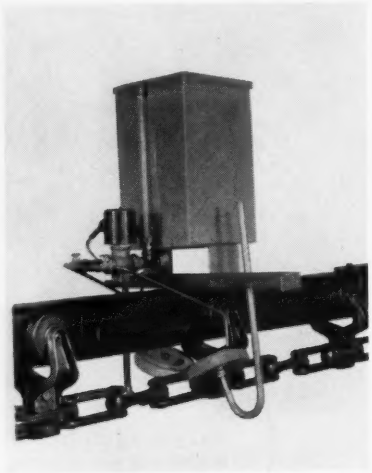
An improved refrigeration oil has been announced by Sun Oil Co. Suniso 3G is designed to work well with all modern refrigerants, including Freon-22, Isotron-22 and Genetron 141. The lower floc point, greater stability, and increased copper-plating resistance of new Suniso 3G permit more efficient operation of compact modern refrigeration units. This oil was announced at the recently held 10th Exposition of the Refrigeration and Air-Conditioning Industry in the International Amphitheatre in Chicago from Nov. 18 to 21. Additional information can be obtained from the Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.

WATER-GRAPHITE DIE LUBRICANT

A newly developed water-graphite die lubricant for application to extrusion dies and permanent molds is reportedly an almost "instant" lubricant in that the addition of water to the concentrate immediately produces a uniform, high-quality lubricant, ready for use. No "digging" or "scooping" of graphite which has settled in bottoms of jars or drums occurs after application of this lubricant. Available in the form of a concentrate which has a jelly-like consistency, the product is at once transformed into a free-flowing lubricant when water is added. No manual mixing or stirring is requested except in unusual instances. Application of the product may be made by spraying, brushing, or dipping. More information on "Graphite Suspension No. 74" may be obtained by writing the Joseph Dixon Crucible Co., Jersey City, N. J.

NEW CONVEYOR OILER

An automatic oiler for conveyor chain links and pins has been designed to apply an even film of oil by direct contact of oil-



carrying felt rollers without mist, spray or drip. The product is usable with all chain-type conveyors but is especially advantageous for food conveyors. Independently hinged rollers apply an oil film simultaneously to each side of the top of the chain. Roller contact with chain is effected manually by means of a lever while an optional solenoid valve automatically starts and stops oil flow. Two needle valves directly control the oil flow to each side of the chain after the solenoid valve is opened. Literature is available on request from the Olsen Mfg. Co., 638 S. Rochester Rd., Clawson, Mich.

SEALER PROTECTS SURFACES

A colorless preservative has been designed for use by maintenance men in industrial plants. Applied to any metal surface that requires protection, this preservative is reported to seal out moisture, resist corrosion of acid solutions, salt water and heat, and prevent oxidation. It is formulated for either spray or brush-on application. Full details are obtainable from the B. O. M. Company, Dept. I, 210 S. Clinton St., Chicago 6, Ill.

TRANSFER AND SUPPLY PUMP

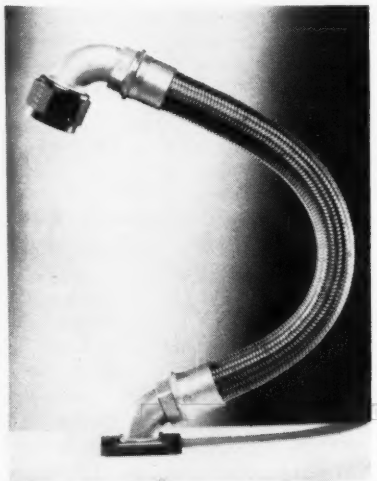
A light-weight, 1:1 transfer and supply pump which can be used on either open top or bung-type drums for time saving dispensing of chemicals, solvents, lubricants, adhesives, inks, dyes and oils is now available. The "rapid-flow" pump reportedly handles chemicals and inflammable fluids safely. This high-volume pump is easily adaptable to 120 lb and 400 lb drums and original containers. The pump operates on air pressures as low as 30 lb and will deliver up to 20 gpm of No. 20 motor oil with 150 lb pressure. For additional information write for Form No. 2974 to Aro Equipment Corp., Bryan, Ohio.

MOLYBDENUM PLATES METAL

A new lubricant "plates" metallic surfaces with molybdenum so that they stay lubricated even under extremes of frictions, pressure or temperature. "Molyconcentrate" can be added to any petroleum oil or grease or used "as is" on sliding surfaces and conveyor chains, particularly where oil dripping is undesirable. For further information, write to John Beach, Sales Mgr., Pacific Lubricants Co., 2807 E. Beverly Blvd., Los Angeles 22, Calif.

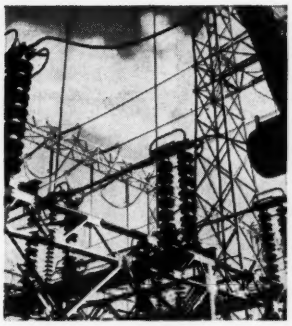
TEFLON HOSE ASSEMBLIES

Introduction of preformed Teflon hose assemblies, designed to minimize design problems and save space and weight, has been



announced. Shaped to almost any configuration under controlled heat, the assemblies are said to minimize design problems by allowing hose lines to clear obstructions and make connections with the shortest possible hose length. The product reportedly eliminates excess metal tubing normally required for special plumbing designs. Further information can be obtained from Stratoflex, Inc., Fort Worth, Texas.

STEEL, with its giant equipment, uses Cities Service lubricants in mounting quantities. The list of Cities Service customers reads like a "Who's Who" of steel.

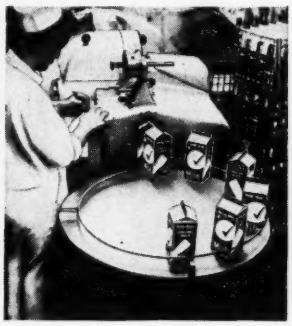


ELECTRIC POWER companies use Cities Service Diesel Lubricating Oil to set low-cost power generating records. Proof again of the high quality of Cities Service Oils.

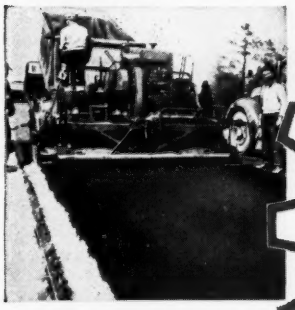
MACHINE SHOPS find Cities Service Cutting Oils the answer to longer tool life and greater precision. Cities Service makes cutting oils for every job requirement.

PAPER requires huge quantities of highly refined wax. The best is Cities Service Pacemaker . . . used for milk cartons, wax paper, straws and many other products.

MINING is both a quantity and quality user of lubricants. Cities Service tailors precision lubricants to serve this basic industry, symbolized by the famous Mesabi Iron Range.



FARMING is more and more a mechanized industry, and more and more an important Cities Service customer. Farming uses more petroleum than any other industry.



ROAD BUILDING calls for enormous quantities of Cities Service petroleum products—all the way from fuels to lubricants to asphalt topping. Future demand looms larger and larger, as America launches the greatest highway building program in history.

Geared to the needs of fast rolling American Industry

AVIATION, with its mounting requirements of higher octane gasolene and jet fuels, finds Cities Service a major supplier. With its ultramodern refinery facilities, Cities Service is capable of producing aviation fuel components in huge quantities.

CITIES SERVICE

BARAGEL*

AN IMPROVED GREASE THICKENER

A unique colloidal gelling agent for compounding greases that are: temperature stable, easily processed, economical. These greases have multi-purpose and specialty applications.

BRAND NEW NOW AVAILABLE

FROM

BAROID CHEMICALS, INC.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
1512 South Coast Life Bldg. Houston 2, Texas

*Trademark of National Lead Company

COVER STORY

Latest technique being exploited to increase research and evaluation laboratory productivity involves the use of automatic instrumentation to control typical routine operations which must be monitored for long periods of time.

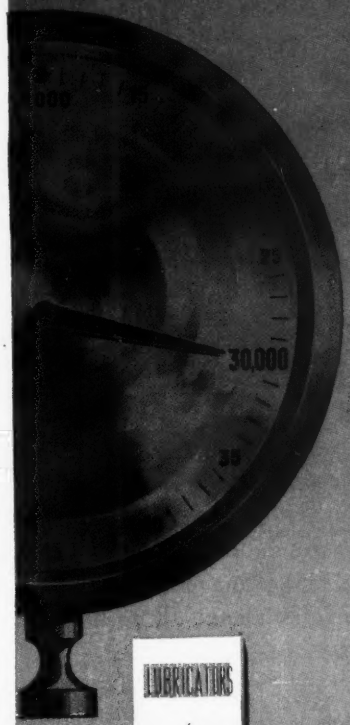
Applicable to the control of variables such as time, pressure, temperature, liquid level, and foam level, the devices monitor one variable and then automatically perform a predetermined mechanical operation. A typical operation might involve the cooling or heating of a chemical reaction, increasing the pressure, decreasing the vacuum, or changing the liquid level.

The new devices, manufactured by Instruments for Industry and Research, Cheltenham, Pa., permit the research technician to keep reactions running overnight, weekends, and during lunch periods. Significant increases in yields are claimed for the installations.

Currently in production by the manufacturer is a "Therm-O-Watch" which clips onto a mercury thermometer or manometer converting it into a temperature or pressure regulator. Another model uses a thermocouple to monitor temperature and time to keep reactions under control. The various units have been designed to be coupled together for control of more than one variable in predetermined sequence.

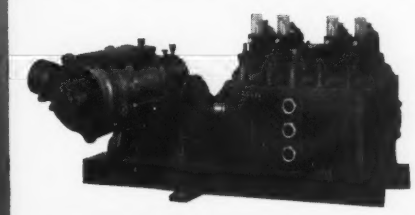
Shown on the cover is a capacitance-actuated controller for monitoring the position of a liquid level in the column. D. R. Conlon, left, head of the new company, is shown examining the monitoring device used with a thermometer with production supervisor Lemmuel Hill. *(Cover photo and story courtesy Instruments for Industry and Research, Cheltenham, Pa.)*

30,000 PSI?
yes- from
MANZEL



Manzel is the accepted source for lubricator requirements up to 30,000 psi. Your operations may not call for these pressures, but Manzel offers you the same outstanding dependability in its regular line of force feed lubricators. Experienced Manzel field engineers will work with you to solve any lubrication problem.

WRITE FOR COMPLETE CATALOG giving specifications and performance requirements to meet any of your lubricator needs.



Manzel

373 Babcock Street • Buffalo 10, New York

Specialists in lubricators and metering pumps since 1898

A New Booklet:

"Industrial Dermatoses - - Protection, Prevention, and Treatment"

Donald J. Birmingham, M.D.; Dr. W. C. Witham; Leonard F. Weber; Nobel H. Schell; M. L. Beardslee; John M. Shaw, M.D.; E. A. Irwin, M.D., C. S. Livingood, M.D.

Eight experts in the field of industrial dermatitis assemble for the first time their experience and investigations in an ASLE-sponsored effort to curb these costly diseases. More than 100 million dollars in manhours are lost to American industry annually as a direct result of one or more forms of industrial dermatitis.

Five medical practitioners, a chemist, and lubrication and resident engineers examine the use and handling of cutting oils, lubricants, and solvent; and discuss protective measures in terms of ointments, housekeeping, and prevention of bacterial decomposition. While no blanket solution is agreed upon, one of the many measures outlined here may prove a solution to your specific plant problem. An informative panel discussion among all participants concludes the booklet.

Mail the coupon below for your copy.

ASLE
84 E. Randolph St.
Chicago 1, Illinois

Please send me ( ) copies of "Industrial Dermatoses." Enclosed is my money order or check @ $1.00 per copy.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

Product Literature

NEW TANK WEIGHING CONCEPT IS DESCRIBED IN BROCHURE

A four-page, two-color brochure describes in detail the new concept of tank weighing as a measurement of tank contents. Covered in the bulletin is the use of the Emery hydraulic load cell as the load sensing device in an Emery weighing system. Combined with various available instrumentation, this load cell can provide indication, recording, printing or controlling of the contents of tanks in the processing industry. Copies of Bulletin 571 are available from the A. H. Emery Co., Pine Street, New Canaan, Conn.

PROTECTIVE COATING ANALYSIS

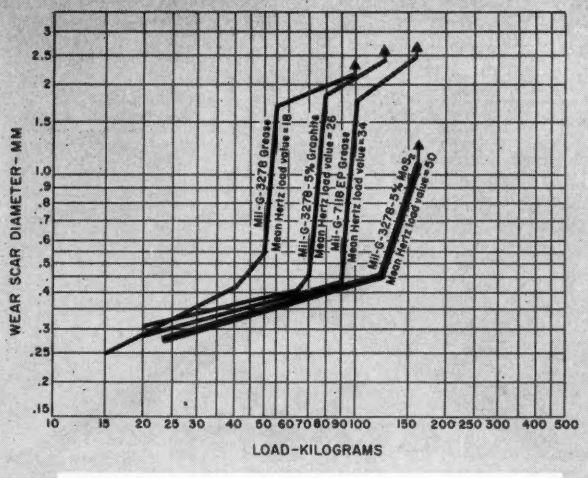
A new technical bulletin presents the features, properties and characteristics of a recently developed super-tough, plastic-type protective coating. Mono-Seal, a balanced chemo-setting synthetic resin coating, is formulated from blends of silicones and epoxies and contains no plasticizers or oils. The coating cures by both solvent evaporation and internal polymerization providing a finished coating which is elastic, durable and tenaciously bonded to basic surface. The bulletin describes the product's basic characteristics and gives data on application, drying times, coverage and surface preparation. A special "value analysis" section provides a guide for economic selection of coating materials. The Mono-Seal bulletin and "value analysis" form are available from Mono-Seal Products, 44 Garden St., Everett 49, Mass.

TEMCO ILLUSTRATED BULLETIN

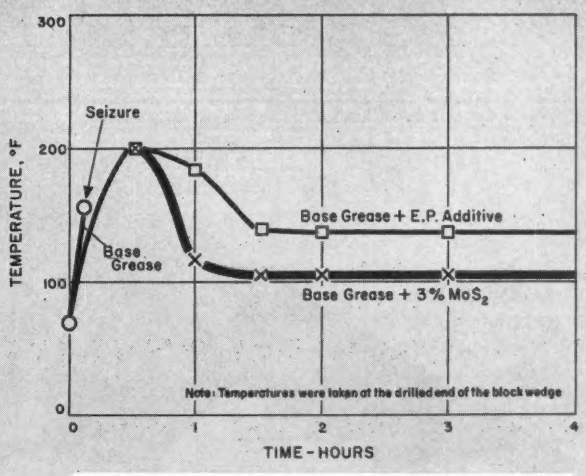
The Thermo Electric Co. has released its 20-page catalog No. 57 containing illustrated descriptions of their Temco line of laboratory and industrial equipment including electric furnaces, hot plates, temperature controllers, pyrometers, flask heaters, and magnetic stirring hot plates. Copies will be supplied upon request on company letterhead to Thermo Electric Mfg. Co., 465 Huff St., Dubuque, Iowa.

PRODUCTS AND PROCESSES FOR SURFACE TREATMENT OF METALS

An 84-page booklet describing the latest developments in surface treatment of metals is now available. The handbook covers rust prevention, mechanical and chemical cleaning, blackening, phosphating and other aspects of the field of metal surface treatment. Write to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa., for "Surface Treatment of Metals".


WEAR SCAR DIAMETER - MM
LOAD - KILOGRAMS
Mil-G-3278 Grease
Mean Hertz load value = 18
Mil-G-3278 - 5% Graphite
Mean Hertz load value = 26
Mil-G-7118 EP Grease
Mean Hertz load value = 34
Mil-G-3278 - 3% MoS2
Mean Hertz load value = 50

4-ball E.P. test shows the superior extreme pressure properties of MoS_2 grease over the same grease without additives. In the same test, grease containing 5% graphite had a mean Hertz load value of 26; the conventional E.P. grease Hertz value was 34.


TEMPERATURE, °F
TIME - HOURS
Seizure
Base Grease + E.P. Additive
Base Grease
Base Grease + 3% MoS2
Note: Temperatures were taken at the drilled end of the block wedge

Timken endurance test clearly shows how MoS_2 functions when added to a base grease. With base grease alone, the specimen seized in about 10 minutes. With MoS_2 added, lubrication was effectively sustained throughout the test at a reduced temperature of about 100°, compared with a temperature of about 130° for the conventional E.P. grease.

Moly-Sulfide additive extends effective lubrication

Laboratory and field tests prove that chassis lubricants containing MoS_2 sustain lubrication after base grease is wiped off

When standard chassis greases are first applied to shackle pins, ball points and other bearing points under trucks, trailers and passenger cars, excellent results are obtained. These greases, however, are subject to mechanical motion, such as reciprocation, pressure, oscillation and shock loading which tend to eject the lubricant.

At this point, chassis grease containing 3% Moly-Sulfide proves its great value. MoS_2 is forced between the rubbing surfaces, adheres to the metal and forms a protective film that prevents galling, welding and fretting. The extent to which MoS_2 sustains lubrication is demonstrated by substantial reduction in wear.

Four tests show how MoS_2 reduces wear

1. **Shell 4-ball extreme pressure test** (see illustration) —MoS_2 addition reduces wear more than 50%, increases load capacity about 70% over base grease.

2. **Falex 2-hour wear test**—As the chart here shows, MoS_2 sustains lubrication, as proved by a reduction in wear, by an average factor of 500.

Grease	Loss in weight of specimen
Lithium-base	1,000 mg.
Lithium-base plus 2% MoS_2	1.98 mg.—average of 3 runs

3. **Timken endurance test** (see illustration)—MoS_2 sustains lubrication well beyond the capabilities of the base grease alone, and at a lower temperature than conventional E.P. grease.

4. **Simulated shackle bolt service test**—oscillating friction machine—3% MoS_2 addition virtually doubles the effective lubrication of a lithium base chassis grease —is far more effective than conventional additions.

Hours to failure—average of 2 tests

Additive	None	3% MoS_2	5% ZnO	15% ZnO
Dry	350	564	336	555
Wet	162	264	109	85

On-the-road use proves MoS_2 prevents chassis wear

A St. Louis company reports no noticeable wear on chassis parts of auto transport trailers, since they selected an MoS_2 chassis grease.

Based on their own tests, several major automobile and truck manufacturers use—and recommend—MoS_2 grease for torsion suspension units, ball joint suspension, as well as for many other critical-wear areas.

Moly-Sulfide greases are available from many producers today. For a list of the manufacturers of these greases—which includes several major oil companies—and for a copy of "Molybdenum Disulfide as a Grease Additive," write to Department 38, *Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.*

- Withstand higher operating temperatures (Up to 75° hotter than lithium based greases)
- Are water resistant (GA-10 greases are insoluble in water)
- Give improved bearing performance (last as much as 2-3 times longer than ordinary soap based greases)
- Have superior work stability (hold up better under severe operating conditions)
- Are resistant to radiation damage from X-Rays, gamma rays, beta rays and neutrons (GA-10 greases maintain good gell structure up to 500 megaroentgens of gamma rays)
- GA-10 greases have higher ASTM dropping points (in excess of 580°F.)
- Are compatible with other types of greases
- Have excellent pumpability in either pressure or automatic feed systems (GA-10 greases are faster flowing than most soap gelled greases)

The unique properties of Oronite GA-10 gelling agent makes possible the production of high performance grease lubricants for a variety of applications. Whether you make multipurpose grease lubricants, automotive greases, aircraft, marine or special purpose greases you can now make them better with Oronite GA-10.

Call or write the Oronite office nearest you for detailed information.
Send for technical bulletin describing properties of Oronite GA-10.

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4461

Lube Lines

by A. F. Brewer*

The Pay Off

The popular conception of *pay off* assumes a solely monetary consideration. Where lubrication is concerned, however, there are other related benefits. Indirectly they all lead to profit by reducing cost and expense. As such they all are of vital concern to management.

Let's see how these benefits of increased machine life, more pay load, lower operating costs, greater safety and reduced maintenance contribute to our advantage.

INCREASED MACHINE LIFE

It is axiomatic that if machine parts can be prevented from premature wear-out, the life of the machine as a whole will be extended. Materials—particularly steels—contribute to this durability when they are metallurgically adapted to the service involved, and are of the required hardness, toughness and tensile strength. These characteristics are not enough, however, when machine parts are in motion with respect to each other, as for example, gear teeth, ball or roller bearing mechanisms or chain links. They must be further protected by lubrication. Nor is it enough to assume *just* lubrication. The lubricants which develope lubrication must be tailored for the job, physically capable of functioning in the lubricating systems and chemically adapted to the service conditions. These latter may present requirements which demand additives specially designed to meet the service.

MORE PAY LOAD

Metallic construction is, of course, the basic requirement as to load carrying capacity. Then the designer includes a factor of safety to meet overload possibilities while at the same time he studies the alloy make-up of the steels. Sometimes high carbon will suffice. In other cases nickel, chromium, tungsten, vanadium, molybdenum or manganese may be included in the alloy to impart characteristics such as resistance to wear under high impact stresses or to increase electrical resistance in case stray currents might be encountered — as in turbine or generator service where circulating oils are involved.

Effective lubrication insures greater pay load because the machine can be continuously operated at overspeed and under high load conditions when the lubricating film is strong enough to resist the squeeze-out, throw-off effects of such service. Film strength is the criterion. Operating management must not "price-buy" when selecting the proper type of E-P lubricant for service where greater pay load is to be carried.

LOWER OPERATING COSTS

Modern production costs require that the attendant operating costs be kept as low as possible. A sound, well-built machine must naturally be provided, the component parts of which are designed for perfectly synchronized motion. When these parts can function continuously so that there is no overheating, no abnormal power consumption, no shut-down for adjustment, maintenance or repair, the unit operating cost of production should be low. One proviso holds, however. These objectives can be attained only when the lubricating system is functioning with equal dependability and when the lubricants employed are able to carry the load and keep temperatures and power consumption in line.

GREATER SAFETY

This reacts directly upon the plant pocketbook. When machinery is designed for safe operation and in service is run with this in mind, everybody will profit. It hurts to be hurt. In a machine, this may simply involve increase in repair or maintenance costs with reaction upon the insurance. With plant personnel, however, an unsafe machine or a set of adverse operating conditions may mean injury, hospitalization, loss of time and income, and possible litigation.

The metallurgist studied safety when he devoted many hours of research to alloy steel formulations and physical testing for fracture, stress, strain and wear-resistance. The designing engineer bore this in mind when he planned the mechanisms built with these safe alloys. The modern automobile is significantly one of the safest and most durable of these mechanisms — when it is adequately lubricated and intelligently and legally operated. As a matter of fact, lubrication can dictate whether any machine is operating for greatest safety. Obviously, faulty lubrication or the use of an unsuitable lubricant can lead to wear, higher temperatures, increased power consumption, chemical change in metallic structure and ultimate metal failure. When this happens, anything can happen. It's not well to be around a machine under such conditions. What's the preventive? Again, greater attention to choice of lubricants, more consideration of lubrication performance as a factor of safety.

REDUCED MAINTENANCE

Mechanized industry today regards maintenance cost as more important than first cost. The latter can be included as a plant investment item. The former, however, is an ever-present nemesis; almost regardless of whether or not it is justified, somebody in the front office may want an explanation. No wonder there is so much interest in keeping maintenance costs down. This objective is more apt to be attained when greater attention is paid to quality in the selection of materials and less to price-saving. i.e. use of suitable alloy steels for strategic machine parts and subsequent selection of lubricants to protect these parts. Low cost maintenance means low cost production because there is normally less time out for repair and less loss of production. The lubrication engineer can play an active part in this program when he is able to develop maintenance costs and balance them against cost of production and unit cost of lubrication. Such data can be vivid proof of the wisdom of combining premium machinery with premium grade lubricants and using modern application methods to protect both.

*Consultant, and author of *Basic Lubrication Practice.*

ASLE News Notebook

Compiled by
R. D. McCormick

Committee Reports

INDUSTRY RELATIONS

This committee is inactive. (See Board Actions.)

INDUSTRY-RELATIONS

This committee has been dropped. (See Board Actions.)

HANDBOOK ADVISORY

The committee is composed of 20 people currently at work contacting the various authors chosen to write the various sections of the handbook.

ANNUAL MEETING

The Cleveland Section as host for the 1958 Annual Meeting have requested permission to sponsor a cash award for the best paper or presentation of a particular subject.

EXHIBIT ARRANGEMENTS

Twenty-one of the 37 available booths for the 1958 Exhibit have been committed. This is a much higher percentage than a similar period in previous years and no difficulty is anticipated in selling the remaining booths.

ANNUAL MEETING SITES

No further work has been undertaken by this committee since the selection of Philadelphia as site for the 1961 Annual Meeting.

Board Actions

Minutes of the June 4, 1957 meeting of the Board of Directors were approved (57-16.)* A recommendation of the Executive Committee relative to the elimination of the June meeting of the Board was approved (57-17.) The report of the Treasurer was accepted (57-18.) Withdrawal of funds to cover operations and expenses during the final quarter of 1957 was approved (57-19.)

By action of the Board of Directors (Oct. 8, 1957, Toronto) the appreciation of the Society and recognition of the service rendered by Mr. E. E. Bisson and the Joint Conference Committee was acknowledged, and the President was requested to prepare a letter to Mr. Bisson and the committee attesting the Board's appreciation (57-20.) The Industry Relations Committee was placed on an inactive status (57-21) and the Industry Representative Committee was dropped as an official committee of the Society (57-22) by board action.

To permit local recognition of the best paper presented before the Annual Meeting in Cleveland, April 22-24, 1958, the Board authorized the Cleveland Section to sponsor an award which would be selected by a local awards committee from manuscripts received prior to April 1 (57-23.)

Ladies attending the 1958 and subsequent Annual Meetings of the Society will be charged a registration fee of $5.00 if they participate in the Ladies' program (57-25.)

*Numbers in parentheses refer to official motions recorded in the Board Minutes.

ASLE-SAE Chicago Sections Plan Lubrication Conference

Plans are being completed for the Joint Automotive Lubrication Conference co-sponsored by the Chicago Section ASLE, and the Chicago Section Society of Automotive Engineers, scheduled for March 11, 1958 at the Knickerbocker Hotel, Chicago. Registration will begin at 8:00 A.M.

Six papers are scheduled and tentatively include:

"Low Temperature Behavior of Motor Oils"

"Lubrication Requirements of Outboard Motors"

"Octane Numbers from Motor Oil"

"An Engineer's Look at Industrial Lubrication"

"The Wear Problem and Techniques Involved in Determining Wear"

"Railway Journal Roller Bearing Lubrication"

Technical sessions are scheduled to start at 9:00 A.M., with three papers presented during the morning session and three in the afternoon. A tentative schedule of registration fees for the conference has been listed as follows:

Technical Sessions, luncheon, and preprints of all papers — $5.25

Evening Dinner — $4.25

No extra charges will be made for guests attending the conference. Further information will be released within the next month. Requests for copies of the advance program sent c/o Lubrication Engineering will be forwarded to the Program Committee.

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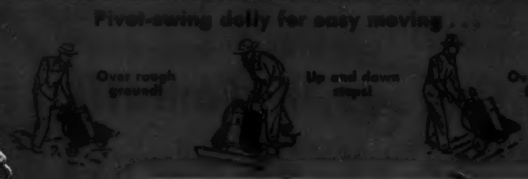

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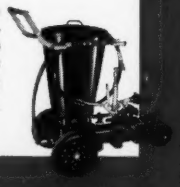
Handles heaviest greases—even in cold weather. No air pockets! Capacity, 40 lbs. Develops up to 5,000 lbs. pressure . . . delivers 11 oz. of fibrous or 17 oz. of light-bodied lubricant per minute at 70°F. *Model 6288.*



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RESEARCH APPLICATION EDUCATION MAINTENANCE

Journal of the American Society of Lubrication Engineers *Vol. 14 No. 1 January 1958*

ASLE TRANSACTIONS

It has been the consistent policy of ASLE to progress as rapidly as possible in all phases of the lubrication field and to provide its members with pertinent information as well as an outlet for their publishable research.

As we enter the new year, your Society of course will continue its policies, and at an ever increasing rate. As a starter for 1958, ASLE has just made a great stride forward in the publication field. As the Society continued to grow, the number of papers submitted has grown to the point where the facilities of our Journal *Lubrication Engineering*, are taxed.

Fortunately, an excellent solution was found before the situation became critical. We are pleased to announce that the Society has concluded arrangements for a new publication to be known as *ASLE Transactions*.

The *Transactions* will be the outlet for many of the technical papers received and besides solving an immediate problem, provide a custom publication which will greatly aid and encourage the pursuit and dissemination of fundamental data leading to the knowhow and progress of tomorrow.

The *Transactions* in no way detract from *Lubrication Engineering*. On the contrary, the value of our monthly Journal will be increased since the change permits the inclusion of more lubrication-in-practice type articles. *Lubrication Engineering* will, of course, continue to carry technical articles along with the usual news items and reader services.

Initially the *Transactions* will be published on a semi-annual basis. This should make possible rapid publishing of papers presented at the annual meeting and the lubrication conference. As many papers as desirable may be included in this publication, the first issue of which is expected in April. We know you will be happy to hear that *Transactions* will be published by Pergamon Press, Inc., publishers of high quality scientific books and journals.

We hope you will be pleased with the new system.

J. O. McLean, *President*

A New Thickener

For Multipurpose Lubricating Greases

R. J. Rosscup, D. R. Oberlink, and W. L. Hayne
Standard Oil Company (Indiana), Whiting, Indiana

A new organic thickener for lubricating greases is prepared by reacting an isocyanate with an amine in a mineral oil suitable for grease use. The resultant greases have low thickener content in which the fibers resemble those of lithium soap. They possess high drop points and excellent resistance to oxidation, water, working, and leakage. Field tests have shown them to lubricate successfully under conditions of extreme temperature and in the presence of water and corrosive chemicals. They should broaden the range of industrial applications for multi-purpose greases.

Lubricating greases that will function satisfactorily over a broad temperature range are needed for many industrial, military, and automotive applications. Although soap-thickened greases are still widely used, the recent trend has emphasized development of other materials suitable as thickeners for multipurpose greases. Organic thickeners[1, 3, 6] other than soap, and such inorganic materials as clays[2] and hydrophobic silica[5] give greases that withstand higher temperatures than soap greases.

A potential thickener must meet several requirements to merit consideration. It must be dispersible in oils in small particles, must have surface properties that produce and maintain thickening, and must have no deleterious effect on grease properties such as oxidation stability, mechanical stability, lubricity, and water resistance. Only a few classes of organic compounds have the high melting points and thermal stability necessary in a high-temperature thickener. Certain aryl ureas used as thickeners with silicone oils give satisfactory service in high-speed ball bearings at 450°F[6]. Studies of similar organic compounds have resulted in the development of a thickener for mineral oils that meets all of the requirements.

The new thickener is formed by reacting an isocyanate with an amine in a mineral oil. It has been nicknamed DAC because of the diamidocarbonyl linkage present. The electron micrographs in Figure 1 show the similarity of the DAC thickener fibers to those of lithium-hydroxystearate, and the difference from those of aryl-substituted urea and silica.

Greases made with DAC are smooth, bright, feathery, and similar in appearance to the best lithium greases. The drop point is 100°F higher than that of a lithium-soap grease. With a high-VI mineral oil of 500 ssu viscosity at 100°F, only 6 percent of thickener is required for a grease of No. 2 grade and 8 percent for one of No. 3 grade. Thickener concentration may be further reduced by using oils of higher viscosity. These low concentrations are probably related to the size and shape of the thickener particles[4].

LABORATORY EVALUATION

Because thickeners can only be evaluated in greases, several greases made with DAC thickener were tested in the laboratory and in the field. Thermal stability, water resistance, mechanical stability, oxidation stability, leakage resistance, and rust prevention were evaluated for DAC-thickened greases by laboratory tests. Compatibility and storage stability were also studied. Typical laboratory properties of a No. 2 DAC-thickened grease are compiled in Table I.

One of the outstanding features of a DAC-thickened grease is high-temperature performance. This feature has been evaluated in bearing, actuator, and thin-film panel tests. The life of an uninhibited grease in the ABEC-NLGI bearing tester is shown for three different temperatures in Table I; even longer bearing life is possible with inhibitors. In an aircraft actuator operating under a

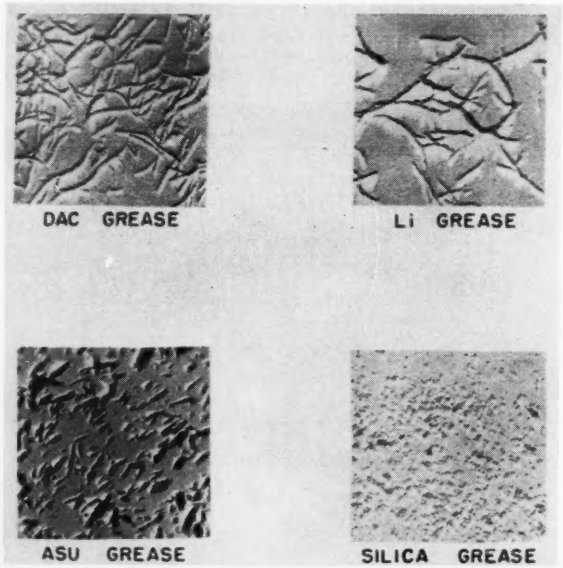

Figure 1. Electron micrographs of thickener particles.

TABLE I. TYPICAL LABORATORY PROPERTIES OF A DAC-THICKENED GREASE

High-Temperature Stability		
Grease life at 250°F., 10,000 RPM: hours[a]	2500+	b
Grease life at 300°F., 10,000 RPM; hours[a]	700+	b
Grease life at 350°F., 10,000 RPM; hours[a]	250	b
Aircraft-Actuator Test at 375°F., 200-lb. load; cycles	2600	
Thin-Film Test at 350°F., 4 days; % change	18	
7 days; % change	—40	
Water Stability		
ASTM water resistance	No Loss	
Water absorption[c], %	100	
100,000 Strokes with 10% water, % change[d]	6.0	
Water leaching, % wt. loss[e]	0.4	
Mechanical Stability		
ASTM Worker		
Penetration change after 60 strokes	+5	
Penetration change after 100,000 strokes	14	
Roll-Stability Test		
Penetration change after 4 hours	—12	
Penetration change after 500 hours	45	
Oxidation Stability		
ASTM Bomb		
Pressure drop, lbs./in.^{2} in 100 hours	2.5	
Pressure drop, lbs./in.^{2} in 400 hours	9.0	
Leakage Stability		
Cone-and-beaker, 210°F.[f], % loss	3.0	
Pressure leakage[d], % loss	3.5	
ASTM wheel-bearing test, 250°F.	0.3	
Rust Prevention		
Free-water corrosion test, rating[g]	1	

a Federal Standard No. 791, Method 331.1
b No oxidation inhibitor present
c Army-Navy AN-G-3a
d Military Specification MIL-G-10924A
e Bureau of Ships Navy Specification 14-L-5
f Federal Standard No. 791, Method 32.1.1
g CRC Test

200-pound load at 375°F, DAC grease lubricated successfully for 2600 cycles; the actuator showed only a small weight loss. Conventional multipurpose greases operate for less than 50 cycles and show large weight losses. Pictures of metal panels coated with thin films of a DAC-thickened grease and a conventional grease are shown in Figure 2 before and after heating to 350°F. After 5 days of exposure, the DAC grease had nearly the same worked penetration as it had before exposure; the conventional grease hardened and cracked.

The organic nature of the thickener provides good water resistance. There is no grease loss in the ASTM Water-Washout Test. The grease can absorb 100 percent or more water without injuring its structure or consistency. In the water-stability test of specification MIL-G-10924A, in which a sample of grease containing 10 percent water is worked for 100,000 strokes, the grease softens less than 10 percent. The water-leaching test of Federal Specification 14-L-5 shows a satisfactory loss of less than 0.5 percent.

The mechanical stability of DAC grease is excellent. The change in penetration upon working is small and may be in either direction. Upon extended working to 100,000 strokes in the ASTM worker, the grease is about 5 percent softer. The four-hour roll-stability test likewise affects the penetration no more than 5 percent; after 500 hours, the grease softens only to a No. 1 grade.

Figure 2. Performance of Terephthalamate and conventional greases.

In the ASTM Oxidation-Stability Test, pressure drops less than 10 pounds in 100 hours with an uninhibited sample. The grease responds well to conventional inhibitors, and the 10-pound drop can easily be forestalled to 400 to 500 hours.

The grease shows little oil leakage in the cone-and-beaker and the pressure test of MIL-G-10924A. In the ASTM Wheel-Bearing Test at 250°F, it showed only a trace of leakage and no grease loss.

Rust-preventive characteristics of DAC grease are similar to those of the best uninhibited soap greases. In humidity-cabinet tests, steel panels coated with this grease show less rusting than those with soda, lithium, or calcium greases. With an inhibitor, the grease passes the CRC free-water corrosion test.

The results of compatibility tests are shown in Table II. DAC grease can tolerate large amounts of widely different contaminating greases. Excellent results in the 250°F wheel-bearing test, the oven-leakage test at 212°F, and mechanical-stability tests were obtained, even with relatively high concentrations of lithium, silica, or sodium greases. Even conventional calcium grease, with a temperature limitation of 175°F, was tolerated satisfactorily to 25 percent concentration with little change in drop point. For all four greases, the drop point remained at 410°F or above with up to 50 percent contamination.

TABLE II. COMPATIBILITY OF DAC GREASE

Contaminating Grease	Penetration Change		Oven Leakage,[a] % Loss	Drop Point °F.	250°F. Wheel Bearing Loss, g
	100,000 Strokes	4-Hour Roll Stab.			
None	14	−12	3.0	480°	0.3
50% Lithium	31	2	4.4	410°	0.3
50% Hydrophobic Silica	−18	−31	3.3	480°	0.7
35% Sodium	—	21	3.8	427°	2.7
25% Calcium	—	19	3.1	450°	16.1[b]

a Federal Standard No. 791, Method 32.1.1
b Loss at 220°F. = 11.3 g.

Storage stability for any grease is difficult to predict. In a bench test that has proved useful with some of the new types of non-soap greases, DAC grease has shown evidence of good storage life. Quarter-scale penetrations obtained after storage for 10 days at 212°F showed a change in worked penetration of only 6.5 percent. Similar tests over a three-month period at room temperature showed an equilibrium penetration similar to that reached in the accelerated test.

FIELD TESTING

In view of the favorable results of all the laboratory tests, field tests were made to determine if any shortcomings existed that were not apparent in the bench tests. DAC grease was field-tested in a wide variety of applications that present lubrication difficulties. High temperature, high shear, water-washing, and combinations of these were typical problems. In addition, tests were made where contact with caustic or detergent solutions posed problems.

Typical field tests and results with DAC grease are shown in Table III. The first two applications require a grease with good high-temperature characteristics. Greases previously used in oven-conveyor trolley bearings leaked on to the ware, and a build-up of hard residue in the bearings caused the trolley wheels to stick and slide. Similarly, high temperature in a brick kiln tunnel caused hardening of greases in car-wheel bearings. DAC grease showed less tendency to harden and freeze bearings under these conditions.

The next two applications are in steel-mill locations where a grease with good mechanical stability at high temperatures is needed. Other greases used on the liners and slides of a hot-billet shear thinned and ran off. DAC grease retained consistency better and extended the lubrication interval from four times per shift to once per shift. In addition, liner replacements were cut in half. On the hot-bed table rolls, bearing replacements were averaging 50 percent every three weeks. The user reported that DAC grease lasted longer and drastically reduced bearing replacements.

In a paper mill, changes in consistency caused by oxidation and poor mechanical stability resulted in excessive grease consumption and bearing failures on a blower handling 270°F air. DAC grease reduced grease consumption and improved bearing life.

In a power plant, high temperature steam caused greases to thin and lose sealing properties, or to harden and freeze both slip and rotary type joints. DAC grease provided a better seal and better lubrication; no frozen joints occurred.

TABLE III. TYPICAL FIELD TESTS OF DAC GREASE

Application	Operating Conditions	Previous Grease Deficiencies	User's Report After Using DAC Grease
Conveyor trolley bearings; Paint company	400°F. oven	Leakage; Stuck bearings	No leakage or stuck bearings after 5 mo. without relubrication.
Kiln-car wheel bearings; Brick company	400-450°F. oven	Hardening; Stuck bearings	Less hardening. No stuck bearings.
Billet-shear liners and slides; Steel mill	500°F. (intermittently). Heavy load, high shear	Loss of lubricant; Poor lubrication	Lubrication frequency reduced 75%. Liner replacements reduced 50%.
Hot-bed table rolls; Steel mill	250-300°F., high shear	Loss of lubricant; Poor lubrication	Longer grease life. Fewer bearing replacements. (Factor of 15:1)
Glower-fan bearings; Paper mill	275°F., air 1300 RPM	Leakage; Hardening	Longer grease and bearing life.
Steam-expansion joints; Power plant	360°F., steam & condensate	Leakage; Stuck joints	Joints sealed 7 weeks without relubrication. No stuck joints.
Drum-roll bearings; Box-board mill	Extreme water washing	Thinning; Washout	Less washout. Longer grease and bearing life.
Pasteurizer-conveyor chain; Brewery	140°F., continuous water spray	Washout	Extended relubrication period from 40 hrs. to 180 hours.
Tinning-roll bearings; Steel mill	Caustic-water washing	Washout; Deposits	Longer grease and bearing life.
Pumps, motors, miscellaneous equipment; Laundry	High humidity, detergents	Leakage	Reduced consumption.

(Continued on p. 39)

Vacuum Dehydration of Oils

G. J. Topol, S. F. Bowser Company Limited, Hamilton, Ontario, Canada

Water is detrimental to the performance and life of lubricating oils and equipment. Water in oil impairs its lubricating properties and increases the rate of oxidation, develops sludge formation and causes costly corrosion to equipment. Removal of water from oils serving modern high speed and pressure machinery becomes increasingly more important and at the same time more difficult. A new approach to vacuum dehydration constitutes a realistic method of oil maintenance which gives the oil user greater freedom in selecting high performance lubricating oils, irrespective of their demulsibility characteristics.

WATER IN OIL

Water and oil are, for practical purposes, two immiscible liquids. If not agitated, water introduced into a lubricating oil separates readily bygravity. However, any kind of agitation can break up the body of water into small droplets which become dispersed in the oil. In this form, water separates by gravity very slowly. If the agitation is intense and persistent, the existing droplets are liable to be split into still smaller ones until they become microscopic in size. Water finely dispersed or emulsified in the oil becomes practically impossible to separate by gravitational means.

Without agitation, water could not emulsify in the oil. If it were possible to build a lubricating system without turbulence, water would separate completely in a settling tank. Unfortunately, the turbulence in the oil pipes, agitation in the circulating pump and high rate of shear in bearings and control valves are unavoidable. Once the water enters the system, emulsification proceeds quickly, and in time, depending on the type of oil, the emulsion becomes impossible to separate completely by heretofore conventional methods.

Emulsified water is not visible to the naked eye, but it can be detected by the changed appearance of the oil. The oil loses its transparent quality and becomes hazy, opaque, or milky. A microscopic examination shows the presence of a vast amount of tiny droplets of water. The total surface of all droplets represents a considerable area. One percent of water emulsified in 1000 gallons of oil to 5 micron fineness, exposes 500,000 square feet of contact area to the oil. It is this tremendous area of contact between water and oil, that greatly accelerates the process of oxidation, acid and sludge formation and additive depletion. While the coarser part of the emulsified water can often be removed by extended settling or centrifuging, the fine droplets, which constitute most of the interfacial area, may remain in the oil indefinitely.

It is generally recognized that water is an enemy of lubricating oils. There are many possible ways of water entering the oil, some of them beyond human control. Modern high quality oils designed to meet the severe requirements imposed on them by new equipment, are more inclined to form emulsions. At the same time, their high performance depends on numerous additives which are easily dissolved in, or damaged by water. If it is impossible to prevent water from entering the lubricating system, an efficient means of removing it, before it causes permanent damage, would safeguard the lubricated equipment through the oil maintenance.

PRINCIPLES OF VACUUM DEHYDRATION

Separation of water by removing it in the form of vapor, rather than liquid, is the basic principle used in vacuum dehydration. In this way, water can be removed without regard to the degree of emulsification. Even the most stubborn, stable emulsions can be purified because vaporization is independent of the forces of gravity.

Evaporation of water from oils at atmospheric pressure would involve temperatures too high for safe processing of oils. It is therefore necessary to lower the temperature by carrying out the dehydration under vacuum. This is technically covered by Fig. 1, which shows the saturation curve for water. Each point of the curve represents a temperature and pressure under which liquid and vapor can remain in mutual equilibrium.

OVERHEATING OF AN EMULSION

A simple experiment will show that emulsified water seemingly does not follow the equilibrium curve, Fig. 1. A water in oil emulsion will not start boiling at 212° F. and usually even 250° F. is not sufficient to boil out emulsified water. This is especially noticeable when both water and oil are clean and free of dissolved gases. Overheating of an emulsion can be attributed to two phenomena — internal pressure and interfacial tension, both being results of molecular forces.

(a) Internal Pressure. All molecules of a liquid are attracted to each other by cohesive forces. As a result, an internal pressure is created within the liquid. However great this pressure (several thousand psi), it is

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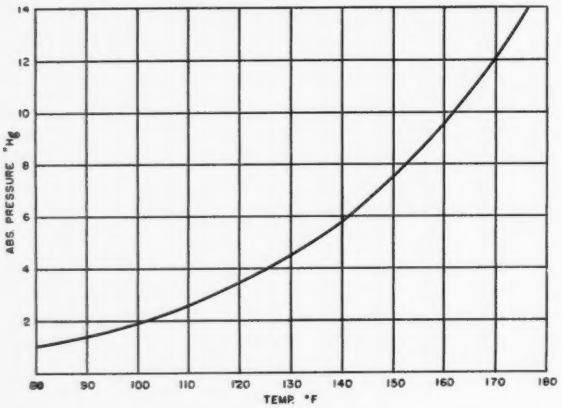

Figure 1. Saturation curve for water.

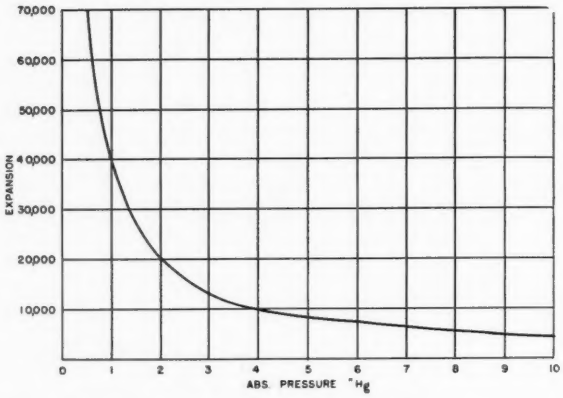

Figure 2. Vapor-liquid volumetric ratio for water.

perfectly balanced and limited to the liquid interior. Thus, internal pressure cannot be measured by any direct method and its effect is limited strictly to activities taking place in molecular scale.

It was proved that perfectly clean water, free of air and foreign matter possesses high tensile strength. The same water can be heated high above the boiling point. In each case, the effect obtained depends on the degree of purity of the water. Observations show that boiling starts on solid particles present in liquid or on the irregular surface of the container.

The logical explanation of overheating seems to be that internal pressure opposes formation of vapor bubbles in the absence of particles initiating boiling. Once a bubble of vapor is created, it becomes itself a nucleus of further boiling.

It is obvious that in an emulsion where water is present in small amounts, isolated from each other and from the container by oil, the possibility of overheating is greatly increased, mainly because of reduced probability of boiling initiating particles being present in each droplet. Our experiments proved that emulsions of clean oils are much more susceptible to overheating than emulsions of contaminated oil.

(b) Interfacial Tension. Due to contractive tendency of the interface, the pressure in each water droplet is larger than ambient pressure. Pressure differential is directly proportional to the interfacial tension and indirectly proportional to the diameter of the droplet. For an average oil, a droplet of 5 micron diameter contains pressure about 4 inches Hg higher than ambient. It can be expected that boiling will not occur at the temperature corresponding to the ambient pressure, but higher.

VAPORIZATION OF EMULSIFIED WATER

A considerable amount of heat is necessary to vaporize water. This heat has to be continually supplied to all water droplets dispersed in the oil. Without an adequate supply of heat, only a small fraction of every droplet could be converted into vapor. This would cool the remaining body of the droplet and further vaporization would be impossible.

The only way to supply heat to a droplet suspended in the oil is through the oil-water interface. Heat which flows from the oil into the water droplet causes a pronounced drop in the temperature of the oil. When 1% of water is removed from oil, the temperature drops by about 20° F.

When an emulsion of water in oil is submitted to pressure and temperature falling below the saturation line (Fig. 1), water will partially or completely boil out. The time required for dehydration of oil under static conditions might be considerably long, which would render this method economically unfit to exploit. In order to procure a process of practical significance, the rate of vaporization must be drastically accelerated.

CONTROLLED VACUUM CONDITIONING OF OILS

The removal of water from oils by means of vacuum dehydration has many desirable characteristics. Although different types of vacuum dehydrators have been commercially available, this method was used for lubricating oil conditioning only to a very limited extent. The main objections were:

(a) High cost of equipment as compared with settling and centrifuging.
(b) Limited capacity and efficiency.
(c) Too complicated and vulnerable.

The vacuum dehydrating system described below was conceived in an attempt to provide a simple and efficient unit, capable of withstanding severe service. Three different aspects of the process were investigated and developed separately: (1) vaporization of water, (2) removal of vapor, and (3) control of the system.

VAPORIZATION OF WATER

The capacity and efficiency of the system depends on the speed and completeness with which emulsified water is transformed into vapor. Vaporization should proceed quickly, without producing an excessive amount of foam at the same time.

Experiments showed that certain porous media, when placed in contact with the emulsion, greatly accelerate the process of vaporization. The best results were obtained by forcing the oil to flow through the medium. The form of a porous tube through which the oil has to flow, in the direction from inside out, appeared to be the most effective. When the medium is properly selected, it can perform four functions essential for efficient conditioning of oil:

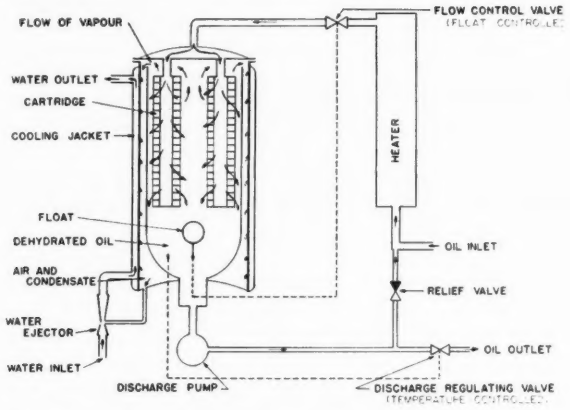

Figure 3. Schematic diagram - vacuum dehydrating system.

(1) It initiates and accelerates the vaporization of water. This increases the efficiency and speed of dehydration.

(2) It distributes the oil in a thin layer over a large surface and breaks vapor bubbles, thus greatly reducing foaming of the oil.

(3) It stops, or slows down progress of water droplets and consequently extends the exposure time. It also improves heat transfer between the oil and water droplet by bringing them into relative motion.

(4) The medium acts as a filter, removing solid particles from the oil in addition to the dehydration. The degree of filtration can be varied.

REMOVAL OF VAPOR

Evaporation of water under vacuum is accompanied by an immense increase in volume. The degree of expansion at different vacuums is shown in Fig. 2. Under 2 inches Hg absolute pressure, about 20,000 gallons of vapor will be generated from every gallon of water.

In the majority of heretofore conventional systems, water vapor is removed by the vacuum pump. This vacuum pump must be very large if the dehydrator is to remove water in any appreciable quantity. This difficulty can be overcome by using a condenser between the chamber and the vacuum pump. The vacuum pump handles only air and gases released from the oil, while water vapor condenses and collects in the condenser. A condensate pump must be provided in order to permit continuous operation of the system. The vacuum chamber has to be heated to prevent condensation of vapor on its walls and the consequent return of water into the oil.

In our system, the need for heating the chamber was eliminated by building the vacuum chamber directly into the condenser, Fig. 3. This combination of evaporating and condensing chamber comprises essentially two concentric shells. The external shell is cooled by a water jacket and serves as a condenser. The internal shell forms a container for the dehydrated oil. Dehydration takes place in porous cartridges suspended from the cover. The internal shell remains hot, since heat losses are minimized by the vacuum existing in the chamber. The top cover is kept warm by the flow of oil into the cartridges. Vapor separated from the oil on the surface of the cartridges, flows through the clearance between the two shells and condenses on the cooled surface in the form of drops, which slide to the bottom.

The vacuum and condensate pumps are replaced by a simple water ejector which is able to handle both the air and the condensate. The same water which operates the ejector is then used as the cooling medium for the condenser.

Omission of the mechanical vacuum pump left only one moving part — the oil discharge pump. This is a slow running gear pump, handling only filtered and dehydrated oil. No oil supply pump is used. Instead, the contaminated oil is drawn through the heater and porous cartridges by the vacuum in the chamber. The float-operated control valve between the heater and chamber regulates the flow of oil.

CONTROL OF THE SYSTEM

To assure proper operation, the temperature of oil entering the vacuum chamber must be closely controlled. The most common method is a thermostat, which turns the electric heater on and off, according to the temperature of the oil leaving the heater. As a result, the oil temperature fluctuates. Besides, when the temperature of incoming oil is very low, the heater might be unable to supply enough heat to elevate the oil to the temperature necessary for dehydration and the unit becomes inoperative.

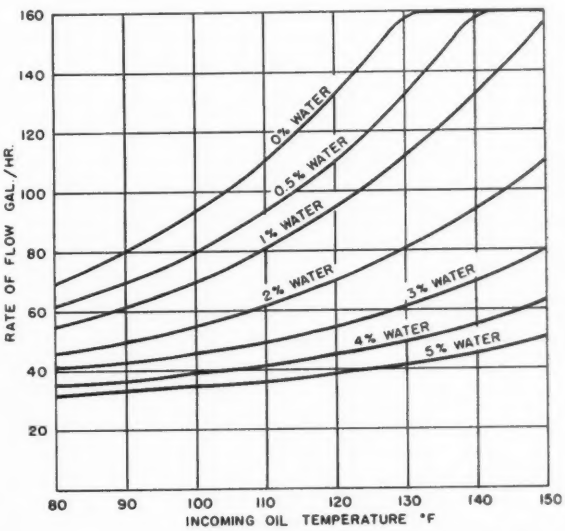

Figure 4. Flow chart for vacuum dehydrating system.

Another disadvantage of this particular arrangement is that the unit processes the oil at the same rate and temperature without respect to the degree of contamination. A highly water-contaminated oil should be processed at a higher temperature and a slower rate than comparatively dry oil. Proper control should, therefore, be able to adjust to the correct processing rate and temperature, according to the temperature and water contamination of the incoming oil. This seemingly complex problem was solved by a very simple means (Fig. 3).

The discharge regulating valve, regulating the output of the unit, is governed by the temperature of the oil

(Continued on p. 32)

Determination of Grease Consistency Using an Automatic Worker Viscometer

H. J. Connors, Westinghouse Research Laboratories, Pittsburgh 35, Pa.

The paper describes an automatic worker type viscometer for evaluating the consistency of lubricating greases. Methods of analyzing the experimental results obtained through use of the instrument are discussed.

NOMENCLATURE

L — Capillary length, in.
Q — Flow rate, in.^{3}/sec
n — Number of passes through capillary
$\triangle P$ — Pressure differential across capillary, lb/in.^{2}
r — radius, generalized, in.
r_w — Radius of capillary, in.
R — Shear rate parameter, sec^{-1}
τ — Shear stress, lb/in.^{2}
τ_0 — Shear stress, yield value for Bingham body, lb/in.^{2}
τ_w — Shear stress parameter lb/in.^{2}
θ — Temperature, °F
V — Volume, total, in.^{3}
μ — Viscosity, absolute, lb-sec/in.^{2}
μ_a — Viscosity, apparent, lb-sec/in.^{2}
μ_p — Viscosity, plastic, lb-sec/in.^{2}
W_K — Work, in-lb
α — The angle between the radius vector through a point in the shear-stress vs shear-rate plane and the shear-stress axis
β — The angle between the asymptote to a shear-rate vs shear-stress curve of a Bingham body and the shear-stress axis

INTRODUCTION

The consistency of a grease, or the degree to which it resists flow, is one of its important properties, and the manner in which the consistency changes with varying conditions is of special interest in many applications such as the lubrication of ball and roller bearings. The consistency of a grease at any time during the operation of such a bearing will determine both its resistance to leakage from and its distribution within the bearing.

The flow properties of most lubricating oils can be completely characterized by a single quantity, the coefficient of viscosity, which depends on the temperature, and is independent of shear rate.

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The flow properties of grease, on the other hand, are affected not only by temperature but also by shear rate and amount of working.

Most of the instruments in popular use for measuring grease consistency fail to embrace all the variables necessary to give a complete picture. Single point instruments such as the cone penetrometer fail to indicate the effect of shear rate on consistency. Single pass instruments such as the ASTM pressure viscometer, although showing the effect of varying shear rate, do not permit investigation of the influence of working on grease consistency.

The limitations of single point and single pass instruments have prompted investigators to develop devices capable of yielding more complete consistency information.

In this paper an automatic worker viscometer of the capillary variety is described that is felt to provide consistency data that is more complete and meaningful than is obtainable with the more commonly used devices.

Developed to study the effects of temperature, amount of working, shear rate and shear stress on grease consistency, the instrument possesses ease of operation coupled with a rapid but reproducible method of obtaining data covering a wide range of conditions.

Preliminary data for two common greases are presented and methods of analysis are discussed.

The fundamentals of capillary flow are available from the literature[1, 2, 3] however for completeness some basic considerations will be reviewed.

Fundamentals of Lubricant Flow

The data obtained from capillary flow experiments are often analyzed[1] by plotting a shear rate parameter R against a shear stress parameter, τ_w.

The parameters may be calculated from the relationships:

$$\tau_w = \frac{\triangle P r_w}{2L} \qquad [1]$$

$$R = \frac{4Q}{\pi r_w 3} \qquad [2]$$

where $\triangle P$ is the pressure drop required to maintain a volumetric flow rate, Q, of the substance being tested, through a capillary of length L and radius r_w.

If, for a given material, the experimental plot of τ_w versus R is a straight line passing through the origin, the material is a Newtonian liquid.

The consistency, or τ_w versus R curve for a Newtonian liquid at a given temperature is shown in Figure 1. The ratio τ_w/R is constant for all values of R and is by definition the coefficient of viscosity, or simply, the viscosity μ of the Newtonian liquid. The viscosity is numerically equal to cot α. For a given liquid α will vary with temperature, increasing as the temperature increases.

Fortunately, for engineering purposes most lubricating oils behave substantially as Newtonian liquids.

Lubricating greases, however, do not conform to the simple Newtonian relationship. A typical consistency curve for a grease at a given temperature is shown in Figure 2. The curve has an intercept on the stress axis and the ratio τ_w/R varies with the shear-rate.

A common method of expressing consistency utilizes the concept of apparent viscosity μ_a where

$$\mu_a = \frac{\tau_w}{R} \qquad [3]$$

The apparent viscosity at any one point on the curve is numerically equal to cot α, where α is angle between the radius vector through the point in question and the stress axis. However, α varies from point to point on the curve, hence a large number of experimental points are required to adequately describe the consistency curve.

Mahncke and Tabor[3] by visual experimental determinations of velocity distributions for grease flow in tubes, and Singleterry and Stone[2] by flow rate experiments have indicated that greases may behave substantially as the special type of plastic solid known as a Bingham body.

The relationship between shear stress and shear rate for the Bingham body is expressed

$$\tau = \tau_o + \mu_p \frac{du}{dr} \qquad [4]$$

where τ is the shear stress on a fluid element; du/dr is the rate of shear or the difference between tangential velocities on parallel planes of the fluid element divided by the distance between the planes; τ_o, a constant, is the yield value or threshold stress that must be exceeded before flow commences; μ_p, a constant, is called the plastic viscosity.

Using the Bingham body relationship of equation [4] Buckingham[4] developed an equation for plastic flow which, when written in terms of the consistency parameters τ_w and R becomes

$$R = \frac{\tau_w}{\mu_p}\left[1 - \frac{4}{3}\left(\frac{\tau_o}{\tau_w}\right) + \frac{1}{3}\left(\frac{\tau_o}{\tau_w}\right)^4\right] \qquad [5]$$

Assuming that greases behave as Bingham bodies, equation [5] provides a more meaningful relationship between the consistency parameters than the apparent viscosity treatment of equation [3] since equation [5] definitely predicts a yield value, the existence of which is in no way indicated in the empirical equation [3].

The Bingham body concept is also attractive in that its application permits grease consistency at a particular temperature to be uniquely characterized by two numerical constants, τ_o and μ_p that have definite physical significance.

Due to the finite yield value exhibited by grease, entrance and orientation losses associated with capillary flow should be taken into account in making fundamental consistency calculations. An evaluation of such losses will be the subject of further investigation. For the purpose of the initial preliminary investigation these losses were not evaluated.

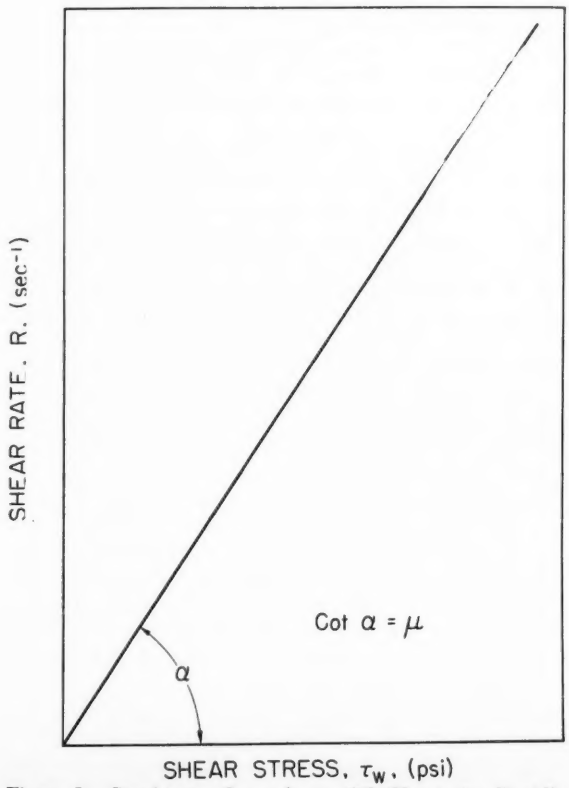

Figure 1. Consistency Curve for an Oil (Newtonian liquid)

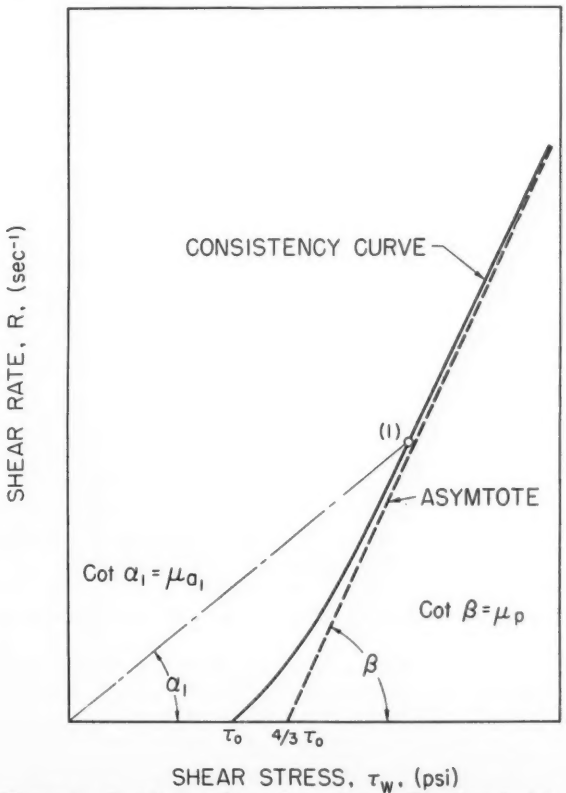

Figure 2. Consistency Curve for a Grease (Bingham body)

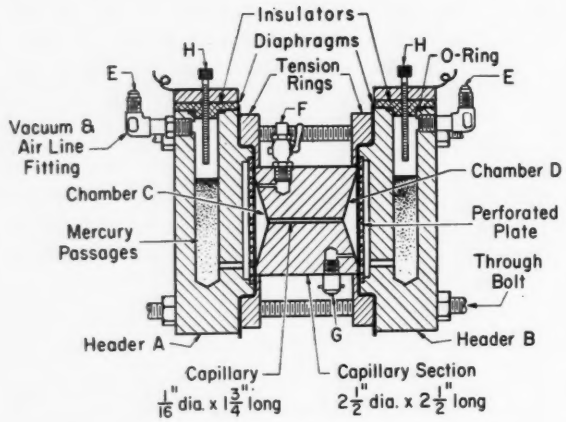

Figure 3. Worker Viscometer

Most of the work that has been carried out regarding capillary grease flow has been concerned with determining the relationship between shear stress and shear rate through use of either the apparent viscosity or Bingham body concepts.

There is, however, another important property, thixotropy, that complicates the task of grease consistency testing and the application of test information to flow problems. For the purposes of this discussion thixotropic materials are materials that show a time-dependent loss of consistency upon application of shear.

Thixotropic behavior in some greases may cause a three or four fold decrease in apparent viscosity with continued working. Thixotropic considerations are therefore of obvious practical significance, as a grease which initially may be of adequate consistency for a bearing application may, upon continuous operation, work down to a state in which it can no longer be retained in the bearing.

The working down of a grease can not be measured in the usual single pass devices.

Some investigators attempt to resolve this difficulty by subjecting samples to a known number of strokes in a grease worker and then testing them in a single-pass viscometer. However, it would be more desirable to have an instrument in which thixotropic behavior could be measured without interrupting the shear process. The worker type instrument of this paper was designed to meet this requirement.

EXPERIMENTAL APPARATUS

The apparatus automatically passes grease back and forth through a capillary connecting two chambers without requiring the presence of an operator. The driving force is derived from pneumatic pressure applied to elastic diaphragms that expand into the chambers.

Essentially, the apparatus consists of a capillary section and two identical header sections, A and B, as shown in Fig. 3.

The capillary section contains two conical grease chambers, D and C connected by a 1/16-inch diameter capillary, 1¾ inches long. Valves and passages are included for use during the loading operation.

Each header section has passages to guide the flow of mercury, the pressure transmitting fluid, to the elastic diaphragm which is held against the header section by the tension ring that bolts to the main body of the header. The contact screws, H, and the mercury form an electrical switching system in conjunction with solenoid air valves which alternately pressurize, then vent to the atmosphere —first one header, and then the other. In this manner the grease is passed back and forth through the capillary. The volume V of grease thus moved, which is constant once the electrical contacts are set, is determined by measuring the maximum and minimum mercury levels in the vertical passage of one header, the passage diameter being known.

The time required for grease passage through the capillary is obtained by scaling the distance between "pips" made by a marking pen actuated from the electrical relay system on a constant speed chart paper, the shorter the time required for grease passage, the shorter the distance between "pips". A stroke counter is used to keep track of the number of passes through the capillary.

The test temperature is maintained by immersing the apparatus in a controlled-temperature bath.

The driving pressure, and hence the shear stress, is set by a pressure regulator and read directly from a pressure gauge.

With the apparatus described the applied shear stress may be varied to obtain as many experimental points as are necessary to plot a consistency curve. The automatic cycling feature provides an easy method for following thixotropic behavior of a grease sample, overcoming the inadequacy of the single-pass devices.

DISCUSSION OF RESULTS

In the following discussion the types of analysis possible with the instrument will be stressed rather than a detailed analysis of a particular grease. Test results are presented for two common greases

Grease A: Mineral oil of 98 centistoke viscosity at 100°F, thickened with 7-9 percent lithium soap.

Grease B: Mineral oil of 54 centistoke viscosity at 100°F, thickened with 35 percent sodium soap.

Two test procedures may be followed to obtain the necessary data.

In method one, a fixed air pressure was applied and the grease worked back and forth through the capillary. The developed shear rate, as evidenced by the time required per pass, was recorded for various values of total passes. In this manner, the progressive loss in consistency due to thixotropic breakdown was followed. Tests were run at several different pressures for each of several temperatures.

The results may be examined by the method of Fig. 4. The figure is a plot of shear rate R versus the number of passes n at each of several different driving pressures for grease A at 120°F. For each pressure the shear rate is seen to initially increase rapidly with the number of passes, the rate of increase diminishing as working continues. For each pressure there is a limiting number of strokes after which the shear rate approaches a constant value. The grease at this time is thought to be in a state of thixotropic equilibrium, i.e., for the conditions of temperature and pressure prevailing, the rate of consistency breakdown equals the rate of buildup.

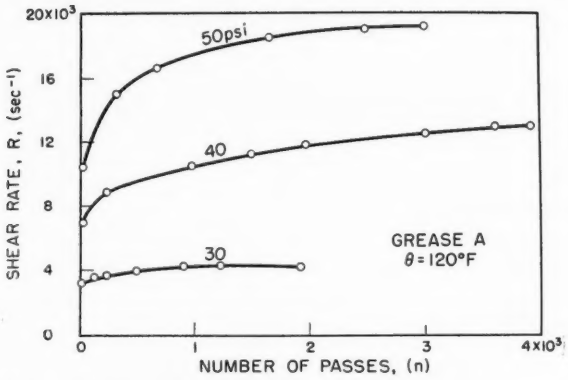

Figure 4. Shear Rate versus Number of Passes

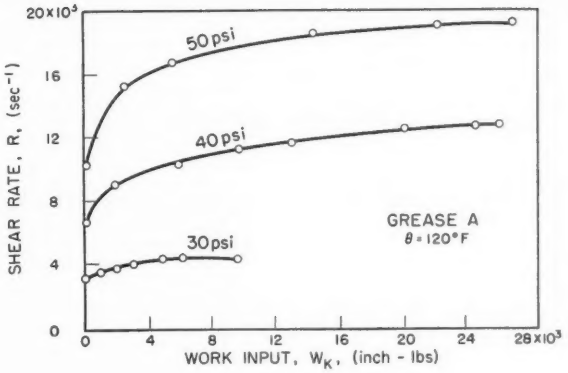

Figure 5. Shear Rate versus Work Input

From Fig. 4 it would be possible to derive consistency curves, τ_w versus R for various amounts of working by obtaining shear rate values from the several pressure curves at a constant number of passes, n. This is the method employed by several investigators using other type worker devices.

However, it appears evident that a sample of grease tested for 100 strokes at, say, 50 psi driving pressure, would have undoubtedly been worked more than a sample of the same grease subjected to 100 strokes at a driving pressure of 10 psi.

As the Buckingham equation for the consistency curve does not take into account any thixotropic changes, the implicit premise is entailed, that, if the Buckingham equation is to be used in interpreting the experimental data, each test point on the consistency curve must correspond to material worked the same amount.

Therefore, it is felt necessary, in utilizing data obtained by the first test method, to replace n, the number of passes, with a more suitable work parameter.

Work input in any incompressible flow process is equal to the product $\triangle PV$, where $\triangle P$ equals the driving pressure and V the volume of material moved. Hence, for a given number of strokes, n, the work parameter for the viscometer becomes $\triangle PVn$. With V in cubic inches and $\triangle P$ in pounds per square inch, the unit of work becomes the inch pound. The product $\triangle PVn$ will be denoted by the symbol W_K.

It should be mentioned here that the mechanism of grease breakdown is a complex subject and one that is not fully understood. Possibly, due to the thixotropic nature of grease, the most valid type parameter might be a rate of work input or power parameter.

Fig. 5 is a plot of W_K versus R, using the samples and data of Fig. 4. The same general trends prevail as in Fig. 4, however, rate values corresponding to various pressures at constant W_K determine a consistency curve for which the material at each point has received the same physical quantity of work.

Fig. 6 shows such a consistency curve for grease A at 120°F. Calculation using equation [5] enables characterization of grease A for the particular temperature and amount of working by τ_o equal 0.153 psi and μ_p equal 14.3×10^{-6} reyns.

Plotting τ_o versus W_K it is noted that the yield value decreases with increased working (Fig. 7). This phenomenon is in accord with observations made by Singleterry and Stone[2].

The experimental data may also be examined in terms of apparent viscosity. Fig. 8 gives comparative information for greases A and B both worked at the same temperature and stress.

To provide a concise overall summary of the type of grease consistency data that may be obtained using the first method of testing the three dimensional plot of Fig. 9 was made using as coordinates the shear-stress, shear-rate and work parameters. The surface was developed using experimental data for grease A at a constant temperature of 120°F.

The apparent viscosity μ_a, is equal to cot α. As may be noted μ_a varies both with shear-rate and with work-input at constant shear-stress. The curve of intersection of the surface on the shear-stress versus work-input plane is seen to be the locus of the yield values for various amounts of work-input.

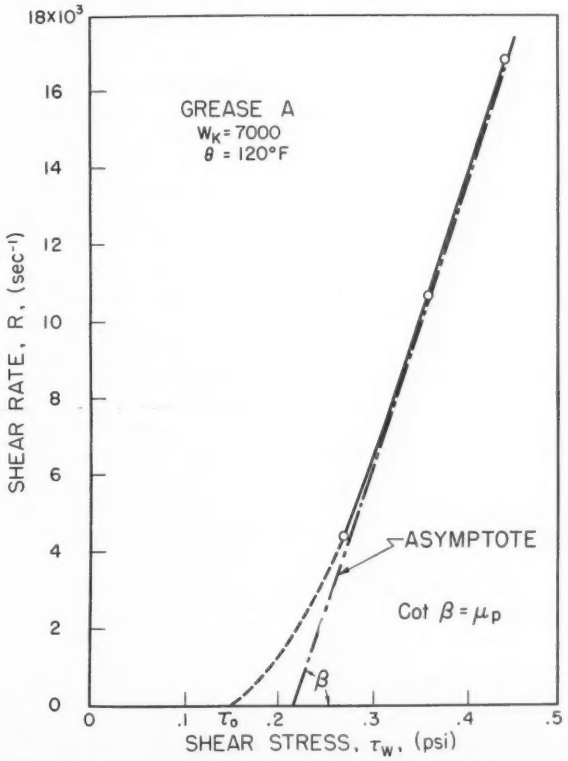

Figure 6. Consistency Curve Derived from Figure 5

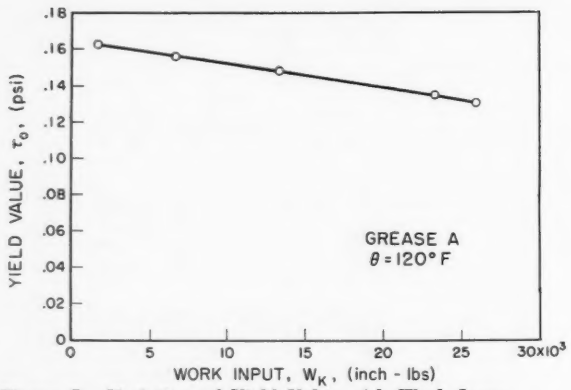

Figure 7. Variation of Yield Value with Work Input

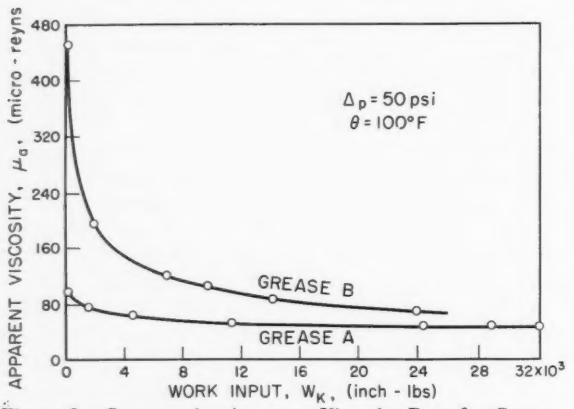

Figure 8. Comparative Apparent Viscosity Data for Grease A and Grease B

The second method of testing consisted of running the driving pressure up and down on the same sample, to obtain consistency curves directly. It was felt that by taking rapid readings, the effect of additional working would be minimized and all points of the consistency curve would be in substantially the same worked condition. This testing method is complicated by a hysteresis effect that was noted upon examining test results. The following discussion is based on Fig. 10 and describes a test conducted for the purpose of illustrating the effect.

A sample of grease was worked at 50 psi to a sufficient extent that the change in shear rate with working had reduced to a small value. The pressure was decreased in 10 psi steps to 20 psi, raised again in steps to 50 psi, and the cycle repeated again. Shear-rate values were taken at each pressure. It was found that the curve obtained with descending pressures did not coincide with the curve obtained with ascending pressures, the descending values of shear rate being higher, thus forming a loop. The fact that the loops from both cycles coincide closely clearly indicates a hysteresis effect not dependent on a permanent change in grease consistency.

The hysteresis effect may possibly be explained in part by the supposition that under low shear rates the grease fibers remain in disorderly and tangled condition. At higher shear rates the fibers are straightened out and aligned, reducing the viscous friction between adjacent layers. As the shearing stress is reduced the fibers require an appreciable time to regain their former state of entanglement, hence the hysteresis loop.

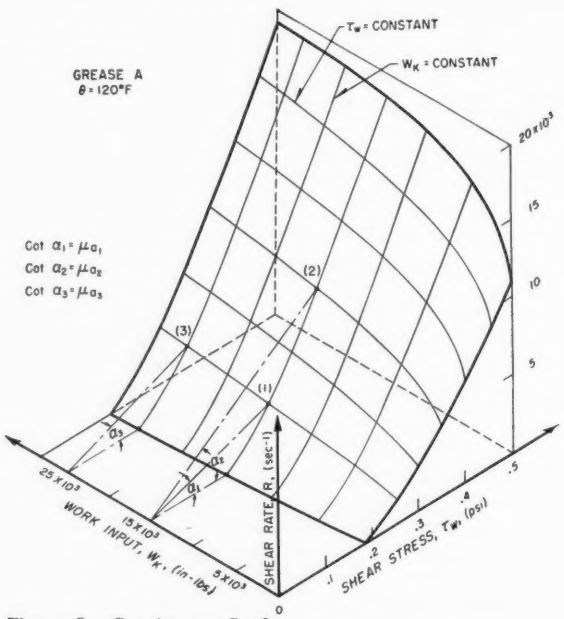

Figure 9. Consistency Surface

In this connection, Hotten[5] has demonstrated the increase in polarized light transmission under flow as compared to stationary conditions of a grease in a transparent capillary. Also Puddington and Gallay,[6] with the aid of a micromanipulator have demonstrated fiber orientation under the application of shear stress in a grease.

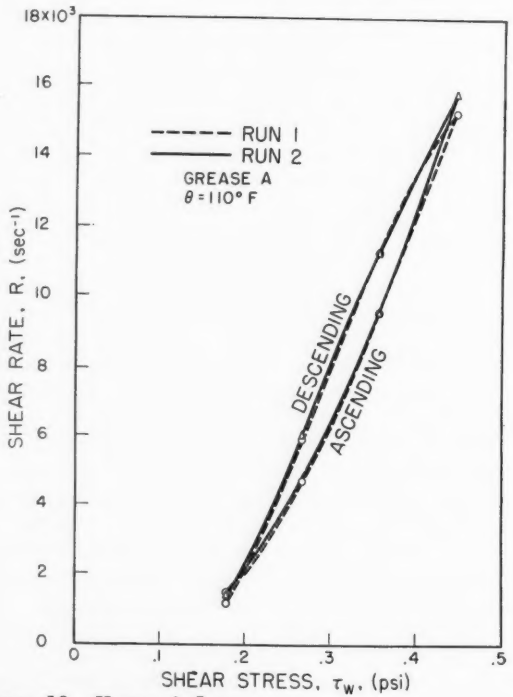

Figure 10. Hysteresis Loop

A meaningful correlation of the data obtained from either method of testing to the Buckingham equation for the consistency curve will require further testing and an evaluation of the influence of entrance effects on consistency measurements.

(Continued on p. 40)

Russian Research on Lubrication and Wear

Douglas Godfrey, California Research Corporation, Richmond, California

This paper lists Russian organizations where lubrication research is conducted, scientific Russian publications, and translation services in the U.S. The Russian research is varied, comprehensive, methodically conducted, and represents a great deal of time and effort. Their papers are well worth examining. Russian and Western procedures are similar, but the Russian research appears to be less advanced.

The Russians are actively engaged in studies of the kinetics of lubricant additive action. Radioactive isotopes of S and P are used to measure amounts of film formed. Sulfur and phosphorus adsorption increased to a maximum amount with increase in concentration of additive, temperature, and time of immersion. These results, coupled with many four-ball machine wear tests, led the Russians to conclude that the effectiveness of such additives lies in a protective film mechanism.
Surface active molecules decrease metal plasticity during deformation. The application of this mechanism to the shearing process of cutting is an important contribution in the field of cutting oil additives.

INTRODUCTION

Knowledge of research conducted by others in a given field is essential in this competitive age. Not only does the knowledge minimize duplication of effort and thus save time and money, but it provides stimulus for new ideas. Russian scientists are progressing rapidly in the field of lubrication, friction, and wear. In the United States many of us are faced with the problem of locating the Russian literature and obtaining translations.

Russian scientists are much better informed of research work in the United States than English speaking scientists are of research in Russia. One reason is that many Russian scientists are fluent in English and most journals are readily available to them. Another reason is that the Academy of Sciences has established an Institute of Scientific Information which reviews and abstracts 1000 Russian and 9000 foreign publications, publishes an abstract journal every other week, and supplies translations in about ten days.

The present paper has a twofold purpose: first, to present a sketch of the extent of recent lubrication and wear research in Russia, by indicating where and by whom the research is conducted, where the papers appear, and how to get translations; second, to present results of research in the field of chemisorption of lubricants so that the Russian work can be evaluated.

Research Organizations in Soviet Russia

The leading research organization in the Soviet Union is the Academy of Sciences of the USSR. The members of the Academy comprise a select group of Russian scientists from all fields. The Academy is directly responsible to the Council of Ministers.

The institutes of the Academy are organized under eight divisions. Of these eight, the divisions of Physico-Mathematical Sciences, Chemical Sciences, and Technical Sciences appear to contribute the most to lubrication studies. Each division has numerous laboratories. For example, the Division of Technical Sciences includes the Institute of Petroleum, the Institute of Metallurgy, the Institute of Mechanics, the Institute for the Study of Machines, the Institute of Engineering, and the Laboratory for Motors.

Lubrication research is also conducted in some of the laboratories of the Academies of Sciences of the 13 Union Republics, the 34 State Universities, the Polytechnical and General Industrial Institutes, the Mechanics Institutes, and a large number of mining, metallurgical, and petroleum institutes.

Research in cutting fluids is conducted at the Institute of Physical Chemistry at the Academy. This work is under the direction of Academician P. A. Rebinder, whose name appears frequently in the literature. Lubrication research is carried on in the Laboratories for Wear of the Institute of Engineering of the Academy of Sciences of the USSR and also in the Bearings and Lubrication Division of the Central Research Institute for Machine Building and Metal Working. Basic research on lubrication, oil additives, and greases is carried on at the Institute of Petroleum of the Academy of Sciences in Moscow under the direction of Dr. G. V. Vinogradov. Research with radioactive tracers in lubricant additives has been carried out at the foregoing institute. Yu. S. Zaslavskii is prominent in this type of work.

RUSSIAN SCIENTIFIC PUBLICATIONS

The publications of the Academy of Sciences are the chief source of Russian scientific information in the U. S. The Academy publishes six major periodical serials:

1. Bulletins (*Izvestiia*), a series of eight monthly publications including a Physics series, Division of Chemical Sciences series, and a Division of Technical Sciences series.

2. The Herald (*Vestnik*), a monthly publication containing comprehensive articles.

3. The Proceedings (*Doklady*), a trimonthly publication containing about 200 pages. The articles are

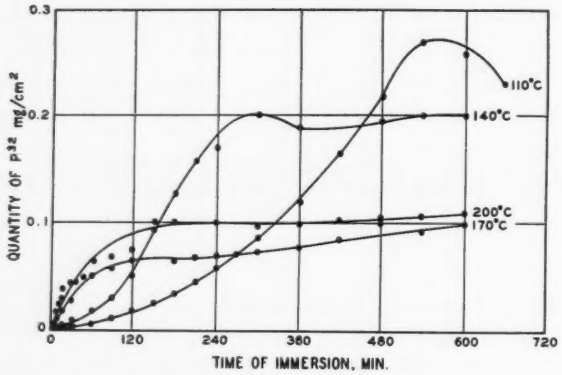

Figure 1. Kinetics of film formation. Phosphorus adsorbed on steel from radioactive triphenylphosphite in oil. (Ref. 1.)

brief and limited to "the most essential results of new research in the field of mathematics, natural sciences, and technical arts. The articles must report completed, unpublished scientific research having a novel, theoretical, or methodological character."

4. Abstract Journals (*Referativnyi Zhurnal*), a series of periodicals covering about 1000 Russian and about 9000 foreign scientific publications.

5. The Advances (*Uspekhi*), survey and review journals for physics and chemistry.

6. Journals (*Zhurnal*), for example, the Journal of Experimental and Theoretical Physics, Physical Chemistry, Technical Physics, and Inorganic Chemistry. In addition, there are the journals: Analytical Chemistry, Applied Chemistry, General Chemistry, The Colloid Journal, Atomic Energy, Automation and Telemechanics, Physics of Metals and Metallurgical Studies, Crystallography, and Applied Mathematics and Mechanics.

This survey by no means lists all the Russian publications. The Library of Congress has listed 1700 Russian scientific and technical serial publications. Of these 350 are not in the U. S.; 200 are represented only by a few issues, and the remainder are scattered throughout the libraries of the U. S.

TRANSLATION SERVICES IN THE UNITED STATES

1. Private translations. The value of Russian research is widely recognized in industry, and many companies employ translators skilled in technical Russian.

2. Independent translation agencies. A number of independent translation agencies will provide single article or whole journal translations at fixed fees. The Consultants Bureau in New York City translates about 20 complete Russian journals, some devoted to pure and applied chemistry and physics. The translations are available on a subscription basis. Other examples of independent translation agencies are Associated Technical Services, P. O. Box 271, East Orange, N. J., Henry Brutcher, P. O. Box 157, Altadena, Calif., and Columbia Technical Translations, 5 Vermont Ave., White Plains, N. Y.

3. Translated titles. At the beginning of 1956, a number of Russian periodicals began to present Lists of Contents in English. Some journals include English summaries.

4. Abstracts. Abstract publications, such as Chemical Abstracts, Metals Review, and API Technical Abstracts, include a large number of Russian articles.

5. Bibliographies. Since 1953 the Scientific Translations Center of the Library of Congress has been issuing a monthly bibliography of translations from Russian scientific and technical literature deposited with or loaned to the Center. These translations may be purchased.

For one who cannot read Russian, the author recommends the following steps for familiarity with Russian research in lubrication, friction, and wear. First, a thorough survey of Chemical Abstracts, API Technical Abstracts, and Metals Review. Second, obtain journals or articles of particular interest and evaluate them for your project. This may require studying figures and tables with the assistance of a translator or, if necessary, a Russian-English dictionary. Third, request full translations from your most convenient source.

RUSSIAN LUBRICATION AND WEAR RESEARCH

This paper reviews 11 translations of recent (1951-1956) Russian papers on the nature of the action between lubricant additives and metals, and covers: (a) the kinetics of formation of sulfur, chlorine, and phosphorus compounds on metals and their effect on wear as determined by the four-ball machine, and (b) the effect of additives in cutting oil on the shearing aspect of cutting.

Russian and Western procedures are similar, but Russian research appears to be less advanced.

A number of the papers describe static experiments, in which metal specimens are heated while immersed in compounded oils. The additive contains a radioactive isotope, and the amount of film deposited is measured by the activity of the metal specimen. In these experiments, the oils, the additives, the additive concentrations, the temperature, and the time of immersion were varied.

The Russians use the four-ball machine almost predominantly to determine wear of various lubricants. The one-minute test at 600 rpm is the only one reported. The materials, as well as the viscosity, temperature, concentration of additive, and, in some cases, sliding velocity were studied as variables.

Experiments were conducted with a laboratory planing machine in order to study the effect of surface active additives on the shearing process.

Tables I and II list the additives and metals that were used in the research described in the 11 references.

RESULTS

Results presented in this paper are a selected few from the large amount of detailed work described in the references.

Kinetics of Film Formation

1. *Phosphorus*

The availability of radioactive isotopes of phosphorus permitted kinetic studies of film formation with phosphorus additives in oil.[1]

The effect of time on the amount of phosphorus adsorbed on steel at various temperatures is shown in Figure 1. If the immersion time is less than an hour, the

TABLE I. METALS USED IN REVIEWED PAPERS

Metals	Description	References
Copper	Red Electrolytic	4, 11, 1, 2, 3, 8
Copper Bronze		1
Zinc	Isotope Zn^{65}	
	Tech. Pure	1, 8
Iron	Technically Pure	10, 11
	Isotope Fe^{59}	1
Steel	Steel-3	4
	Steel-20	4
	SHKH-9, Used for Ball Bearings	4
	30-KHGCH	4
	30-KHGSA Stainless	2
	EYAT-1 Stainless	4
Cast Iron		4
Aluminum	Technically Pure, Rolled	9
Dural		11
Lead		1, 3
Lead Bronze		1, 3
Antimony	Isotope Sb^{124}	3

largest amount of phosphorus is found at 200°C. However, if the time of immersion is 10 hours, the largest amount is adsorbed at the lowest temperature studies (110°C).

Copper was found to be an active acceptor of phosphorus additives.[2] A temperature curve for film formation on copper by triphenyl phosphite is shown in Figure 2.[1] In this system the quantity of phosphorus decreased with increased oil temperatures above 50°C. Maximum corrosion rate was found to be around 170°C.[3]

Lead and lead bronze react intensely with phosphorus additives. In Figure 2 the temperature curves for lead, steel, and copper may be compared. The temperature curve for lead shows a distinct maximum quantity near 140°C. According to Vinogradov et al[2], this temperature was reported as 170°C. Total amount of phosphorus deposits on these metals decreases rapidly with increased temperature.

2. *Sulfur*

The adsorption of sulfur additives onto copper, steel, and stainless steel is shown in Figure 3. The adsorption by copper starts at room temperature reaching a maximum at about 100°C. The total amount of reaction product (assumed to be CuS) decreases above 100°C because of the formation of friable black deposit.[1, 4] The possibility of the loss of reaction products above 100°C indicates that corrosion tests of copper in a sulfur-containing additive may give erratic values. The maximum rate temperature has also been reported to be 160°C[2] and 170°C[3]. In any case, the rate of reaction is high[1], and an increase in concentration of the additive and time of immersion increases amount of sulfur deposited.[1, 2] The adsorption of sulfur onto steel is very slight at low temperatures.[1] The interaction begins between 100°C[1] and 180°C[4] and rapidly increases. One stainless steel (EYAT-1)[4] shows low susceptibility, even at temperatures above 225°C. Generally, the amount of sulfur deposited increases with time. In addition, the rate of adsorption levels off to a maximum at about 200°C[4]. The penetration of sulfur into the steel was demonstrated.[1, 3]

The reaction of sulfur with lead bronze was similar in character to the reaction of sulfur and copper[1]. The

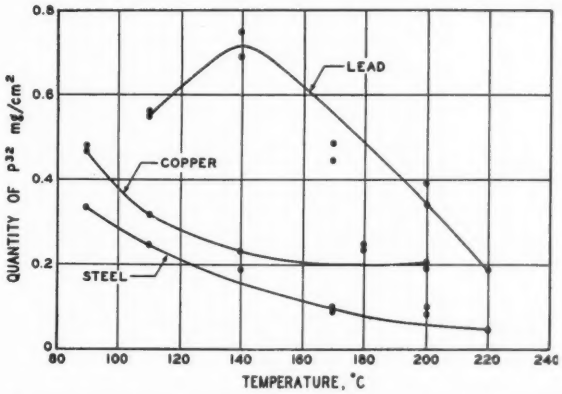

Figure 2. Kinetics of film formation. Phorphorus adsorbed on lead, copper and steel from radioactive triphenylphosphite in oil for 10 hours. (Ref. 1.)

adsorption of a sulfurated oil additive on lead at various temperatures[1] reveals that, if the immersion time is less than an hour, the largest quantities are adsorbed at 200°C. However, if immersion time is 10 hours, the greatest quantity of S is adsorbed at 110°C. This effect is similar to that shown for phosphorus in Figure 1.

TABLE II. ADDITIVES USED IN REVIEWED PAPERS

Additives	Description	References
Acetic Acid		10
Nonylic Acid		10
Stearic Acid		10, 8
Oleic Acid		11, 8
Methyl Alcohol		10, 11
Octyl Alcohol		10
Cetyl Alcohol		10
Sodium Oleate		10
Ethyl Laurate		7, 11
Sulfur	S, S^{35}	4, 1, 2, 3, 6
Dibenzyl Sulfide		6
Dihexyl Sulfide		6
Butanethiol		2
Carbon Tetrachloride		11
Benzyl Chloride		6
Triphenyl Phosphate	With P^{32}	1
Tributyl Phosphite	$(nC_4H_9O)_3$ P	2, 6
Tributyl Phosphate	$(nC_4H_9O)_3$ PO	2, 6
Dibutyl Thiophosphite	$(nC_4H_9S)_2$ P	2, 6
Tributyl Thiophosphate	$(nC_4H_9O)_3$ PS	2, 6
Tributyl Dithiophosphite	$(nC_4H_9S)_2$ (nC_4H_9O) P	6
Tributyl Dithiophosphate	$(nC_4H_9O)_2$ (nC_4H_9S) PS	6
Tributyl Trithiophosphite	$(nC_4H_9S)_3$ P	2, 6
Tributyl Trithiophosphate	(nC_4H_9O) $(nC_4H_9S)_2$ PS	6
Tri(S)butyl Thiophosphate	$(nC_4H_9S)_3$ PS	6
Tetraisopropyl bisdithiophosphate		6

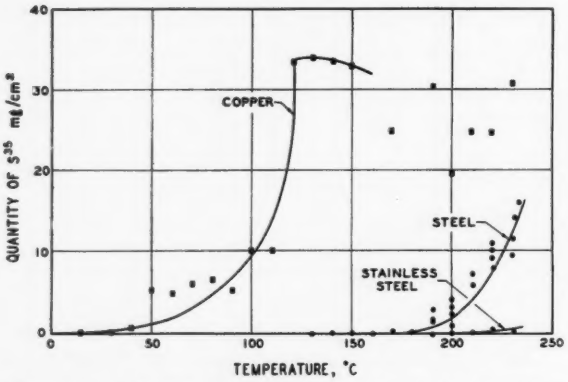

Figure 3. Kinetics of film formation. Sulfur adsorbed on copper, steel and stainless steel from radioactive sulfur in oil for 2 hours. (Ref. 4.)

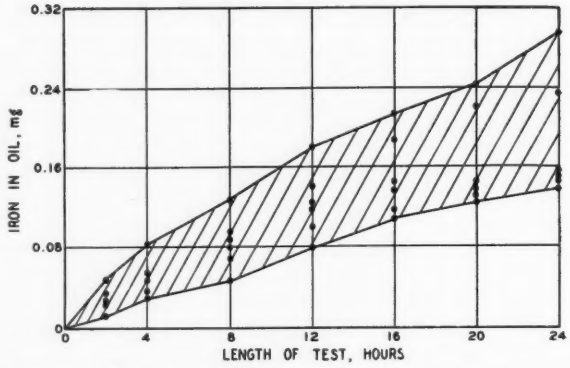

Figure 4. Kinetics of film formation. Corrosion of cast iron by lubricants. (Radioactive iron in MT-16 oil at 170°C.) (Ref. 1.)

Metal Corrosion by Lubricant

While studying metal-lubricant reactions, the Russians have measured the rate at which metal is "dissolved" by lubricants[1]. Radioactive cast iron plates were immersed periodically in test oils in a special apparatus. At various times and temperatures, the radioactivity of the oil was measured. Figure 4 shows that the amount of radioactive iron in the oil increases with immersion time. The oil MT-16 is described only as a lubricating oil. If the oil was uncompounded, this "dissolving" of metal is a new and interesting result. If the oil contained additives or decomposition products, some dissolving is expected. In any case, the application of this technique is worth considering as a supplement to the dynamic methods of detecting engine wear with radioactive metals.

Chemisorption in the Cutting of Metals

The Russians are active in studies of the effect of cutting fluids in the shearing of metals. Dr. P. A. Rebinder has spent many years demonstrating the effect of surface-active molecules on the deformation of metals. The application of this effect to the shear process seems to be a new idea. Therefore, this research will be described in some detail.

Four-Ball Wear Tests

The literature suggests that the Russians' four-ball apparatus procedures are similar to those currently used in the U. S. Vinogradov et al.[5] give details of the Russian interpretation of four-ball wear curves. Generalized results are given in Figure 5 which shows wear curves for base oil compounded with various types of additives: (a) chlorine and thiophosphoric additives give high critical loads and low wear rates; (b) esters of phosphoric acid give high critical loads but permit welding; (c) high concentrations of chlorine give high wear and mild seizure; and (d) sulfides and disulfides give low critical loads and mild seizure.

In Reference 6, the results of four-ball tests on a series of phosphorus-sulfur compounds are described. The data show that susceptibility to wear and seizure for phosphorus-sulfur additives decreases with an increase in the number of sulfur atoms in the molecule. Tri(S)butylthiophosphate was the most effective phosphorus additive in the series. However, wear increased with temperature and sliding velocity, and the P-S compounds permitted welding. It is of special interest that the results show that friction coefficients are independent of the concentration of phosphorus additive. However, the wear curve is concentration-sensitive[6].

Epifanov et al.[7] propose a mechanism by which surface-active molecules and cutting fluids decrease the total work of shear.[7] They hypothesized that the molecules are absorbed into the freshly exposed and chemically-active metal surface at the zone of shear and thereby decrease the plasticity of the metal. The metal is thus em-

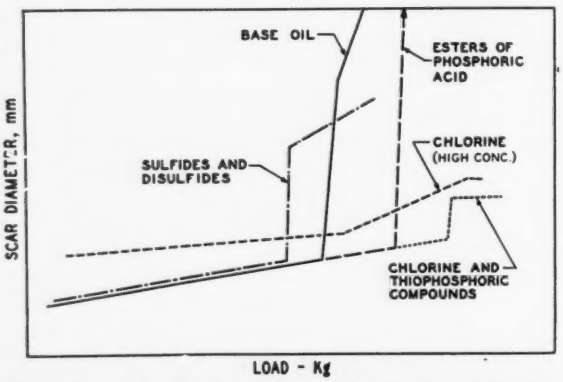

Figure 5. Generalized wear curves for S, Ci, and P additives in base oil obtained on four ball E-P lubricant tester. (Ref. 5.)

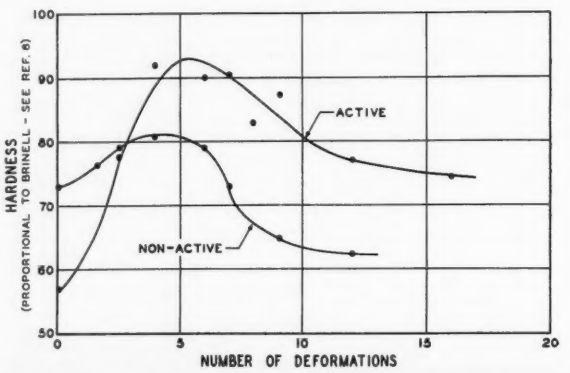

Figure 6. Correlation between hardness and number of deformations for zinc in active and non-active media. (Ref. 8.)

brittled and shear occurs with less total work output. The intrusion of foreign materials into a metal lattice is known, hydrogen embrittlement being an example.

Details of the proposed mechanism are of interest in the field of chemisorption. The active molecules (hydrogen, carbon, oxygen, nitrogen) are formed as a result of decomposition of organic molecules, particularly surface active molecules, catalyzed by the freshly exposed metal. The plastic deformation occurring during shearing results in an excess of free energy which contributes to a lowering of the surface barriers. Also, the creation of new surfaces gives additional free energy calculated at 10^4 calories per mole. (In 1948, Shaw proposed a mechanism which is analogous. He stated that after metals are torn apart, the surface atoms have a maximum degree of unsaturation and are, consequently, very active.) The energy accumulated from deformation and creation of new surfaces is converted to heat; the resulting high temperatures further accelerate the decomposition of the organic molecules. The high temperatures and the activated state of the metal cause a high rate of diffusion into the metal lattice. Increase in the rate of diffusion into the metal compared to normal conditions is a factor of 10^6 at a temperature of 500°K (227°C). The authors of Reference 7 calculated that the rates of diffusion are comparable to the usual cutting speeds. This idea suggests that the diffusion of atoms into the metal can proceed ahead of the shear crack.

Experimental evidence was presented[8, 9, 10] showing a greater hardness of metals after deformation in a surface active medium than in an inactive medium. Figure 6 shows an example for zinc. In the free planing of aluminum[9] the zone of plastic deformation is 2.5 times narrower when ethyl laurate is used than when planed without a liquid. Similarly, oleic acid[11] was shown to reduce shearing forces and shorten chip elements of aluminum, iron, and copper.

ACKNOWLEDGEMENT

The author gratefully acknowledges the assistance of the staff of the Richmond Library of the California Research Corporation, as well as that of Jack de Benedictis, in the preparation of this review.

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Vacuum Dehydration of Oils

(Continued from p. 21)

leaving the dehydrating cartridge. It must be remembered that vaporization of water from the emulsion cools down the oil. Therefore, the degree by which the oil temperature drops, as it passes through the dehydrating cartridges, is proportional to the percentage of water. When the oil is heavily contaminated with water, the temperature in the chamber is lowered by violent vaporization and the discharge valve throttles. This reduces the discharge flow and part of the oil is forced back into the upstream part of the system via a relief valve. The blending of this dryer, hotter oil with the wetter, colder incoming oil, consequently dilutes the water content and increases the temperature of the mixture entering the dehydrating cartridges. This control is continuous and responds sensitively to any change in the composition and temperature of the contaminated oil. It is because of this control that high processing rates can be obtained without danger of any but clean dehydrated oil being discharged from the system. This control also affords the same protection during the warm-up period.

PERFORMANCE DATA AND TEST RESULTS

The system was thoroughly tested under controlled laboratory conditions, as well as in actual field service. The whole system was built into a compact unit which was easy to transfer to numerous locations in order to evaluate its performance in different applications.

The unit was equipped with a 6 KW heater and a ¼ HP discharge pump. It required 3 gpm of water at 40 psi to operate the ejector and the condenser. The discharge control valve was set to open at 140°F. and the operating vacuum was 2 inches Hg absolute pressure (28 inches gauge vacuum). The discharge capacity for different oil conditions is shown in the flow chart, Fig. 4.

Tests were run with different types of oils, up to 3000 SSU viscosity. Under no conditions was excessive foaming in the chamber encountered. The unit was able to withstand severe punishment, such as the sudden change from oil to water. A full range of concentrations, starting with dry oil up to 100% water, were processed without upsetting any part of the system.

Up to the present time, the described system has been laboratory and field tested on the following applications: steel mill lubrication, paper mill lubrication, hydraulic systems, turbine lubrication, synthetic oils, and vacuum pump and compressor oils.

CONCLUSIONS

Vacuum dehydration of oils is an old, well known method. The system presented in this paper is not claimed to be a new discovery. It is purely a different approach to the problem of oil maintenance, on which industrial development imposes increasingly higher standards of performance. The faster and more powerful machinery of today requires new special purpose oils which in turn call for better and more efficient means of maintenance. Current experience indicates that controlled vacuum conditioning is an answer to today's demands for proper oil maintenance resulting in fewer shut-downs and expensive repairs to high cost production machines.

ACKNOWLEDGEMENT

The writer wishes to express his thanks to the S. F. Bowser Company Limited for making this publication possible. He appreciates the understanding and help extended to him by the Management in all phases of the research and development work. For constructive suggestions, he is particularly indebted to Mr. L. B. Baranowski, the Vice-President and Chief Engineer of the S. F. Bowser Company Limited. The enthusiastic co-operation of the research personnel in laboratory and field testing, is gratefully acknowledged.

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Selected literature compiled by members of the Technical committees and Industry Councils of the Society

Literature Abstracts

—— W. E. Campbell, Editor

"Additives with a Purpose," Anon. (The Texas Co.) *v.* 43, *no.* 3, 1957, 25-40.

A review of lubricant additive types and mechanisms of action is given. *(Abstractor: M. I. Smith)*

"Cold Starting with V.I. Improved Multigrade Oils," F. B. Fischl (Esso Research & Eng. Co., Linden, N. J.), H. H. Horowitz, T. S. Tutwiler. *S.A.E. Transactions, v.* 64, 1956, 608-20. Discussion 621-4.

Oil viscosities at low temperatures as measured by engine cranking speeds do not agree with values extrapolated on an A.S.T.M. chart from kinematic viscosities measured in capillary-type viscometers at 100° and 210°F. Engine values may be higher or lower depending upon the relative effect of two opposing factors. These are: 1. deviation of polymer-thickened oils from a straight line relationship on the A.S.T.M. chart, and 2. temporary loss of viscosity at high shear stresses. Estimates of 0°F capillary values, which are better than those currently obtainable by extrapolation, are given by formulae which consider the contribution of specific V.I. improvers to blend viscosities at 100° and 210°F. Properties other than cold starting are briefly discussed. *(Abstractor: M. I. Smith)*

"A Contribution to the Evaluation of Surface-Active Compounded Oils and Emulsions," E. H. Kadmer, *Schweizer Archiv, v.* 23, *no.* 6, 1956, 185-96.

Seizure loads are obtained on 5 E.P. test machines evaluating various types of film-strength additives. The machines employed are: 1. D.S. tester (a smaller version of the Timken machine). 2. Wieland machine (a development of the Almen tester). 3. Shell 4-Ball. 4. A model developed at the Hanover Institute for Petroleum Research. 5. F.Z.G. — a gear test machine. Lack of agreement among these machines prevents extension of individual results to practical use. Turning, boring, and milling tests on emulsions and water-soluble oils give widely different ratings. It does not appear practical to specify test conditions for general use with cutting fluids. *(Abstractor: M. I. Smith)*

"Detergent Oils and Their Dispersive Properties." J. Darbre (Inst. Francais du Petrole), *Revue de l'Institut Francais du Petrole, v.* 11, *no.* 10, 1956, 1298-1312.

Particles of soot dispersed in engine oils tend to coagulate at increased temperatures. Therefore, blotter spot tests or microscopic examinations which are conducted at room temperature may not give a valid picture of conditions inside the engine. It is suggested that these tests be run at elevated temperatures. Four states of particle agglomeration are defined, and the temperature of transition to the next coarser is taken as a criterion of used oil condition. This method is also used to evaluate efficiency of detergents by adding varying concentrations to mineral oils which have previously been in service. *(Abstractor: M. I. Smith)*

"Dynamic Demulsibility Characteristics of Oils," E. W. Brennan (The Pure Oil Co., Crystal Lake, Ill.) and R. G. Moyer. *Lubrication Eng., v.* 13, *no.* 3, 1957, 146-150.

A test method, which is designed to evaluate the water-separating ability of oils under conditions approaching those in actual practice, is described. Data are given for straight mineral, turbine, and paper machine oils. *(Abstractor: M. I. Smith)*

J. Simon (U. S. Steel Corp., McKeesport, Pa.), *Iron and Steel Engineer, v.* 34, *no.* 6, 1957, 93-103.

Some examples of high temperature applications in steel mills are given. Laboratory methods of checking performance properties are briefly described and minimum requirements listed. General performance characteristics of the various types of synthetic and petroleum greases are discussed in relation to dropping points. *(Abstractor: M. I. Smith)*

"How to Reorganize Your Lubrication System." O. J. Seidl, *Mill & Factory, v.* 60, *no.* 4, 1957, 115-7.

A complete renovation of the lubrication program by Combustion Engineering Company at their East Chicago, Ind., plant has corrected many inefficiencies suffered previously. With the new planned program, the number of lubricants was reduced from 35 to 15. The lubricants were coded to simplify purchasing, and storage and wall signs were posted in the lube room to identify lubricants and minimize possible errors. A simplified card system was introduced to guide in the application of proper lubricant in the proper place at appropriate time interval. Cards also acted as a means of checking the functioning of the program. The job classification of men to handle lubrication was re-written to attract personnel with adequate qualifications. Modern lubrication equipment was installed where required for improved handling and application of lubricants. The results of this program have been reflected in reduced maintenance costs and delays. *(Abstractor: E. S. Reynolds)*

"The Low-Temperature Properties of Motor Oils." T. VonHammerich, A. Schmitz, (BV-ARAL AG, Bochum), *Brennstoff-Chemie, v.* 38, *no.* 1-2. 1957, 9-14.

Viscosities of several 10-W, 20-W and cross-graded oils are given at low temperatures as measured with a rotational viscometer and a "visco-balance". In all cases, measured data were higher than values extrapolated on the A.S.T.M. chart from capillary results obtained at 100°F and 210°F. Discrepancies were generally greater for cross-graded products. *(Abstractor: M. I. Smith)*

"Microchemistry in Lubricating Oil Analysis." Anon. (The Texas Co.) *v.* 43, *no.* 1, 1957, 1-12.

A review of micro-analytical techniques and their application to petroleum products is given. *(Abstractor: M. I. Smith)*

"Mine Lubricants Handling." R. B. White, *Mining Congress Journal. v.* 43, *no.* 4, 1957, 122-4.

The suppliers of lubricants and fuels take great pains to ensure that their products are free from contamination. When storing containers it is desirable to have at least under-cover storage or better yet inside storage. Care should be taken never to store petroleum products next to steam pipes or where they can be affected by abnormal temperature conditions. When it is necessary to store drums outside they should be tilted with the bungs uppermost to forestall moisture contamination. Foreign material frequently gets into petroleum products during their transmission and dispensing. Proper supervision and common horse sense will minimize potential contaminations. Adequate storage facilities with periodic cleaning and inspection will contribute much to maintaining products suitable for use. A carefully

(Continued on p. 35)

MOLYKOTE® lubricant sparks design change

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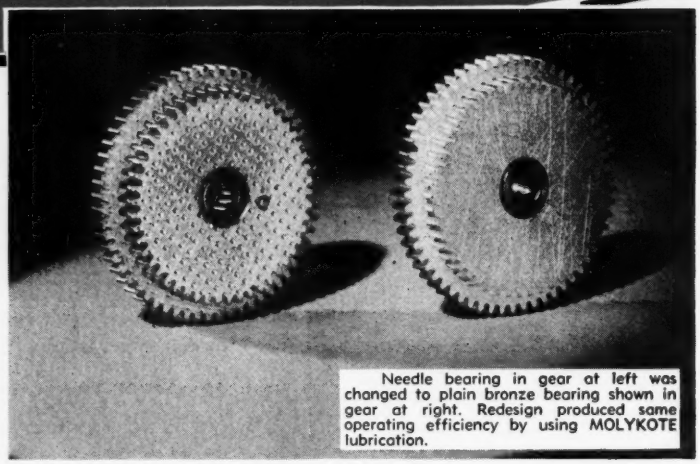

Needle bearing in gear at left was changed to plain bronze bearing shown in gear at right. Redesign produced same operating efficiency by using MOLYKOTE lubrication.

Eagle Signal Corp., Moline, Ill., manufactures the Polyflex Reset Timer, a synchronous motor driven device which trips its contacts open or closed during a time interval. The timer is a precision instrument used to control many industrial operations.

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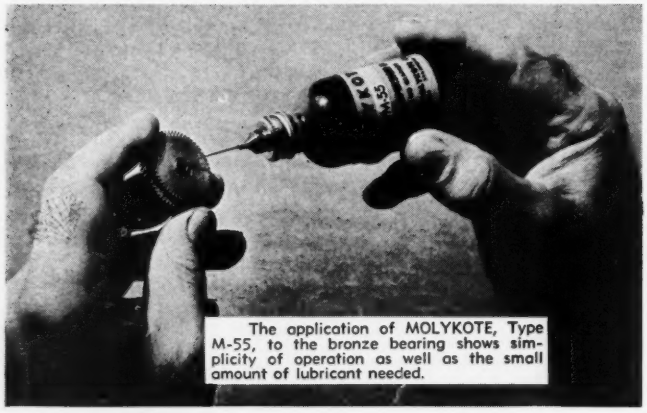

The application of MOLYKOTE, Type M-55, to the bronze bearing shows simplicity of operation as well as the small amount of lubricant needed.

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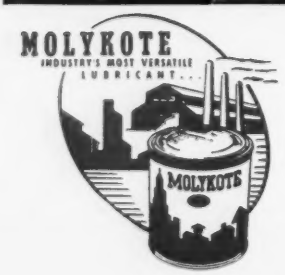

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LUBRICATION ABSTRACTS

(Continued from p. 33)

planned lubrication program will help control required stocks of product and ensure normal turnover. The transferring and dispensing of lubricants underground present serious problems in the mining industry and specially-trained lubrication personnel are certainly desirable under these adverse conditions. Mine crews and maintenance men who exercise due caution greatly reduce lubrication contamination or misapplication and help cut maintenance costs. *(Abstractor: E. E. Reynolds)*

"Radiation-Resistant Greases." J. G. Carroll (California Research Corp., 576 Standard Ave., Richmond, Cal.) R. O. Bolt, B. W. Hotten, *Lubrication Eng. v.* 13, *no.* 3, 1957, 136-40.

Conventional greases subjected to pile and gamma radiation suffer damage to physical properties and performance characteristics. Alkylaromatic fluids with selected gelling agents show superior resistance to radiation. *(Abstractor: M. I. Smith)*

"Relationship of Low-Temperature Cranking Resistance to Viscosity Characteristics of Multigrade Engine Oils." G. K. Malone (General Motors Corp.) and T. W. Selby, *SAE Transactions, v.* 64, 1956, 602-7. Discussion 621-4.

Cranking speeds at 0°F. vary among brands of 10W-30 oils, and are generally lower than obtained with corresponding straight 10W grades. Viscosity measurements at 0°F. show that some multigrade oils do not qualify as 10W, and abandonment is recommended of the present method of extrapolating viscosity to 0°F. from measurements at 100°F. and 210°F. *(Abstractor: M. I. Smith)*

"The Viscosity-Temperature Function." W. A. Wright (Atlantic Refining Co., Phila.) *A.S.T.M. Bulletin no.* 215, 1956, 84-6.

Desirable features of a viscosity-temperature classification system are listed, and the Viscosity-Temperature Function (VTF) is stated to possess all the requirements. A derivation of VTF is given, based upon the rate-process theory of flow. It is defined as:

$$\text{VTF} = \frac{\log \text{kin. vis. } 100}{\text{A kin. vis. } 210} \div \log \text{kin. vis. } 210$$

where A is theoretically a constant for any homologous series, and empirically found to be 2.25 for mineral oils, n-paraffins, and polymethyl siloxanes. Typical VTF values are given, and the relationship with the present VI is shown. *(Abstractor: M. I. Smith)*

"What's Happening in Lubrication." Ted Metaxas, *Mill & Factory, v.* 60, *no.* 1, 1957, 125-8.

Recent trends in industrial lubrication indicate an upgrading of lube manpower and equipment, card scheduling of lubricants and frequency of application, purchase of equipment designed with lubrication consideration, specification buying and centralization of lubrication responsibility. Inventories of lubricants are being minimized by careful study of requirements. Premium lubricants prove economical where justified and properly supervised. The problems related to lubrication are being minimized by adequate training of personnel and cooperative efforts of consumer and supplier. Lubricants certainly have been improved and the multipurpose lubricant has contributed much to advancement in the field of lubrication. *(Abstractor: E. S. Reynolds)*

"The Use of A.S.T.M. Slope for Predicting Viscosities." E. E. Klaus (Pennsylvania State Univ.) and M. R. Fenske (Atlantic Refining Co., Phila.) *A.S.T.M. Bulletin no.* 215, 1956, 87-94.

The slope of the line on the A.S.T.M. viscosity-temperature chart is shown to be more closely related to the % viscosity change per °F than is the V.I. at high values of V.I. The slope is also more valuable as an aid in preparing blending charts of oils containing polymeric thickeners. At very high and low temperatures, both systems may fail to predict behavior based upon measurements at 100° and 210°F. It is recommended that 3 or 4 observations be made to include the temperature range of interest, with the A.S.T.M. slope being used for interpolation. *(Abstractor: M. I. Smith)*

"Development of a Method For Determining The Influence of Lubricants On The Seizure of Pistons in Two Cycle Gasoline Engines." A. Dyson (Shell Research Ltd., Thornton Research Center, England) *Revue de l'Institut Francais du Petrole, v.* 11, *no.* 11, 1956, 1489-95.

Oils are compared by the cylinder wall temperature at which piston seizure becomes imminent. Experiments leading to actual seizure were not reproducible due to destruction of surfaces and necessity for reassembly of the engine. Incipient seizure is defined as that point at which the engine speed is reduced by 50 rpm below its initial value. When run to that point, surface damage is negligible and as many as 50 runs can be made without stopping the engine. *(Abstractor: M. I. Smith)*

"New Viscosity Index En Route to Adoption." C. M. Larson (Sinclair Refining Company) and W. C. Schwaderer, *Petroleum Engineer, v.* 28, *no.* 6, 1956, C 11-14, *no.* 9, C 12-14, C-16.

Shortcomings of the present V.I. system are briefly reviewed, and the theory of the Viscosity-Temperature Index (VTI) is given. To calculate the VTI, measurements of viscosity at 100° and 210°F are required, together with tabulated "R" values of reference oils having the same 210° viscosity as the unknown. The VTI permits blending computations to be carried out on the A.S.T.M. viscosity-temperature chart. VTI is defined as follows.

$$\text{VTI} = \frac{W_U - W_{210}}{W_R - W_{210}} \times 100$$

where

W indicates the ordinate height on the A.S.T.M. kinematic viscosity-temperature chart. The subscripts U and R denote the unknown and reference oils respectively at 100°F, and W/210 is their common viscosity at 210°F. *(Abstractor: M. I. Smith)*

(Continued on p. 38)

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Patent Abstracts

(Compiled by Ann Burchick, Aluminum Co. of America)

Soluble Oil, Patent No. 2,770,596 (J. L. Jezl, assignor to Sun Oil Co.) A soluble oil composition comprising: mineral lubricating oil; alkali metal soap of petroleum mahogany sulfonic acids; alkali metal soap of petroleum naphthenic acids; a saponified oxidation product mixture obtained by partially oxidizing petroleum foots oil in liquid phase at a temperature in the range from 260 to 320°F., and a pressure from atmospheric to 100 psig in the presence of a metallic oxidation catalyst until the saponification number of the oxidation product mixture is within the range from 60 to 120 mg. of KOH per gram, and saponifying said oxidation product mixture with an alkali metal basic compound; 1.75 to 3.0 volume percent of an alcohol consisting essentially of a primary amyl alcohol; and 2.75 to 5.0 volume percent of water; said soluble oil having sulfonate saponification equivalent within the range from 3 to 10 mg. of KOH per gram and carboxylate saponification number equivalent within the range from 10 to 20 mg. of KOH per gram, said saponification product mixture providing carboxylate saponification number equivalent within the approximate range from 5 to 10 mg. of KOH per gram, and said alkali metal soap petroleum naphthenic acids providing carboxylate saponification number equivalent within the approximate range from 5 to 10 mg. of KOH per gram.

Foam-Inhibited Lubricating Oils, Patent No. 2,772,238 (W. Lowe, assignor to California Research Corp.) A foam-inhibited lubricating oil composition comprising a major proportion of an oil of lubricating viscosity and an alkylphenyl polyethyleneglycol ether sulfide.

Pour Point Depressant, Patent No. 2,773,915 (E. R. Baker and M. L. Sharrah, assignors to Continental Oil Co.) The process of preparing a composition suitable as a lubricating oil pour point depressant which comprises reacting chloromethylated synthetic still bottoms prepared by chloromethylating a synthetic still bottoms product which has a boiling range of 260 to 400 C., n_D^{25} 1.574, average molecular weight 210, A.P.I. gravity 15.1, aniline number 73.4 F., percent hydrogen 10.69-1075, percent carbon 88.88-89.37, percent nonaromatics 27.8, percent aromatics 72.2, average molecular weight nonaromatics 245, and average molecular weight aromatics 204 to a chlorine content of 8.34 percent with diwaxbenzene in the proportions of 1 mole of said chloromethylated compound to from about 0.25 to about 1 mole of said diwaxbenzene at a temperature between about 20 and about 30 C. for a period of time between about 5 to 12 hours, in the presence of aluminum chloride and an inert organic solvent, neutralizing the resulting mixture with an aqueous solution of a base, permitting the mixture to separate into an upper layer composed substantially of said inert solvent, said pour point depressant, and a small amount of unreacted chloromethylated still bottoms and a lower layer composed of substantially water, said aluminum chloride, salt, and unreacted base, separating said upper layer and recovering the pour point depressant therefrom.

Method and Apparatus for Applying Lubricants to Sheet Metal, Patent No. 2,774,684 (A. M. Fucinari, assignor to The H. A. Montgomery Co.) A process for preparing a sheet of metal for subsequent drawing, comprising applying to the sheet a film of a lubricating composition having a melting point substantially above the initial temperature of the sheet, the temperature of the lubricating composition as applied being above its melting point, and applying pressure to said film by means of a rolling surface maintained at a finishing temperature between said melting point and said initial temperature of the sheet for reducing the thickness of the film and forcing it into more intimate contact with the sheet while chilling the film to accelerate setting to a non-tacky condition.

Extreme Pressure Lubricant, Patent No. 2,775,558 (M. Fainman, assignor to Standard Oil Co.) An extreme pressure lubricant consisting essentially of from about 75% to about 93% of a mineral lubricating oil, about 5% to about 10% of sulfur-containing lead tallate, from about 1% to about 10% of a chlorinated paraffin wax containing from about 40% to about 70% by weight of chlorine, and from about 1% to about 5% of 9,10-dichlorostearic acid.

Lubricant Compositions, Patent No. 2,776,260 (J. D. Klicker and D. R. Stevens, assignors to Gulf Research & Development Co.) A lubricant composition comprises a major amount of a lubricating oil and a minor amount sufficient to improve the detergency characteristics thereof of a metal salt.

Lubricating Compositions, Patent No. 2,777,819 (P. H. Williams and F. C. Younger, assignors to Shell Development Co.) A lubricating composition comprising a major amount of a mineral lubricating oil and from about 0.1% to 10% of a tertiary branched aliphatic primary alkylamine trichloro-

methanephosphonate, said amine portion of the salt containing at least 8 carbon atoms.

Wire Rope Lubricant Comprising a Blown Petroleum Extract and a Paraffinic Residuum, Patent No. 2,778,780 (J. W. Romberg, assignor to The Texas Co.) A wire rope lubricant consisting essentially of a blend of about 30 to 80 percent by volume of an asphaltic product having a softening point in about the range 140-250 F. with about 70-20 percent by volume of a paraffin base residuum having a viscosity in the lubricating oil range, said asphaltic product being obtained by air blowing a petroleum extract obtained by extracting a paraffin base distillate oil having a viscosity in the lubricating oil range with a selective solvent for non-paraffinic hydrocarbons, said blend having a penetration at 77 F. in about the range 90-120 and a softening point in about the range 130-145 F.

Refining of Lubricating Oils, Patent No. 2,779,711 (L. A. Goretta, assignor to Standard Oil Co.) A process for producing color stable lubricating oil by hydrogenating an unrefined distillate lubricating oil stock derived from a mixed-base crude oil which is characterized by color instability which process comprises contacting the stock with cobalt oxide-molybdenum oxide-alumina hydrogenation catalyst which has been alkalized by incorporation of about 0.5 to 10 mol percent of an alkali selected from the group consisting of compounds of alkali metals and alkaline earth metals, in the presence of hydrogen at a temperature in the range of about 650 to 850 F., a pressure in the range of about 500 to 2500 p.s.i.g. and a space velocity in the range of about 0.5 to 10 W.H.S.V.

Process for Improving Lubricating Oils by Hydro-Refining in a First Stage and Then Hydrofinishing Under Milder Conditions, Patent No. 2,779,713 (E. L. Cole and W. E. Skelton, assignors to The Texas Co.) A method of processing a hydrocarbon lubricating oil stock to enhance the quality thereof which comprises subjecting said lubricating oil stock in admixture with hydrogen and in the presence of a hydrogenation catalyst to conditions of mild hydrogenation such that said lubricating oil stock is converted to an intermediate product of improved viscosity index, and subjecting said intermediate product in admixture with hydrogen and in the presence of a hydrogenation catalyst to a temperature of about 400 to 650 F., a pressure of about 750 to 5000 p.s.i.g. and for a time such that said intermediate product is converted to a lubricating oil of improved oxidation stabiilty.

Low Fluid Loss Composition, Patent No. 2,779,735 (J. L. Brown and M. M. Landers, assignors to Continental Oil Co.) A low liquid loss composition comprising: a major portion of petroleum oil having dispersed therein; a minor amount of oil-insoluble finely divided solids of such fineness as to provide at least about .0025 pound per gallon of oil of particles varying in the size from about 0.005 to 2 microns; and a minor amount, at least .01 pound per gallon of oil, of an "agglutinant."

Production of Lubricating Greases from Oxo Esters, Patent No. 2,779,736 (A. J. Morway, F. Knoth, Jr. and J. H. Bartlett, assignors to Esso Research & Engineering Co.) A process for making grease which comprises contacting in a carbonylation stage a non-aromatic olefin having about 10 to 20 carbon atoms with an aliphatic alcohol having about 1 to 3 carbon atoms and carbon monoxide in the presence of a carbonylation catalyst at conditions conducive to the formation of an ester of said alcohol with an acid having 1 carbon atom more than said olefin, recovering a mixture of said ester with unconverted olefin, introducing said mixture into a mineral lubricating oil, subjecting the resulting mixture to saponification with a metal base at a grease-making temperature of about 280 to 325 F. to form a grease while driving off unconverted olefin and alcohol freed by said saponification reaction, cooling the grease and returning said unconverted olefin so driven off to said carbonylation stage, said lubricating oil being non-saponifiable at the conditions of said saponification.

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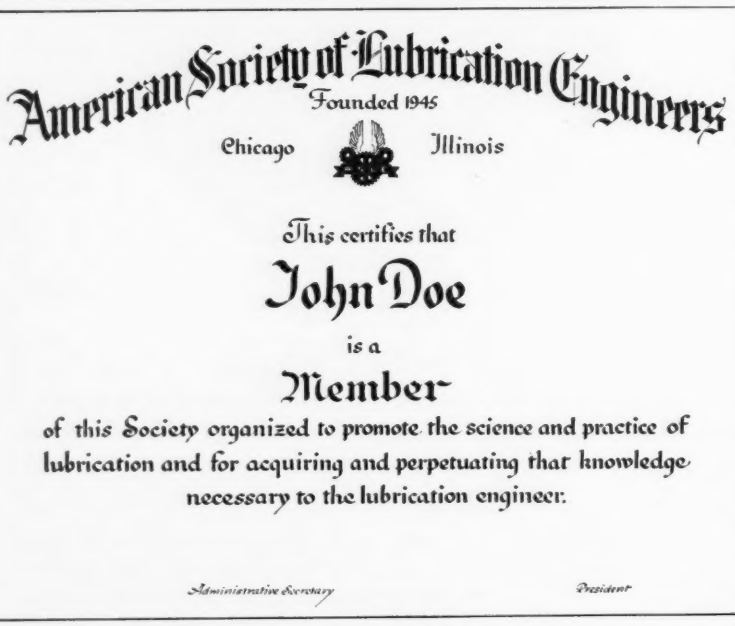
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Section News

Houston — Largest crowd ever to attend meeting of this section heard R. W. Van Sant, Jr., Gulf Research and Development Co. marketing director, speak on "Railroad Diesel Fuels and Lubricants." . . . **Duluth Iron Range** — Cloquet Golf Club hosted section and speaker James Juricich of Cummins Diesel Sales Corp. Subject was "Protective Maintenance." Talk was followed by movie on prevention of dust in diesels . . . **Northern California** — Sydney R. Calish, Jr. of California Research Corp. discussed lubrication of automatic transmissions . . . **Dayton** — Buffet dinner followed by "problem session." Advantages of lubricant specifications for specific industrial needs discussed by R. F. McKibben of National Cash Register Co. S. S. Sorem of Shell Development Co. spoke on "High Temperature Bearing Operation in the Absence of Liquid Lubricants." . . . **Milwaukee** — Money-raising time combined with Christmas party and large meeting turnout . . . **Pittsburgh** — Technical session high-lighted by Socony-Mobil's C. D. Fleming's discussion on "The Functions of Cutting Fluids in Machining Operations." Question and answer period followed . . . **New York** — Schrafft's Restaurant housed dinner meeting featuring Clayton W. Nichols, Jr., Socony Mobil's supervisor of lubricants, speaking on properties and characteristics of modern petroleum base greases. Color movies and slides illustrated the discussion.

GERMAN BOOK REVIEWED

Uber die Wirkstoffe in Legierten Motorenolen by Erich H. Kadmer; published by the Verlag fur Chemische Industrie, Augsburg, Germany, 1957, 90 pages. Price — DM 7.50. (Reviewed by A. Goldschmidt, California Research Corporation.)

This monograph is an up-to-date review of the field of motor oil additives. Within the frame-work of a 90-page booklet, the author succeeded in conveying a surprisingly large volume of information about viscosity-temperature characteristics, polymeric thickeners and their shear properties, pour point depressants, oxidation and corrosion inhibitors, detergents, rust preventives, anti-foam agents, and extreme-pressure additives. Each chapter consists of a discussion of the problems involved, a description of the additives, and a fairly comprehensive patent bibliography up to about 1953. A list of the major additive manufacturers (mainly American) and of their commercial products is appended, including function and chemical analysis. This well organized book, giving a bird's-eye view of a very complex field, should be a welcome addition to the libraries of lubricating oil manufacturers, distributors and patent attorneys.

New Thickener for Multipurpose Greases

(Continued from p. 18)

The next two applications require a grease to perform during extreme water washing. The results show DAC grease has greater resistance to washout and change in consistency than previously used greases.

Caustic water splashing on the roll bearings over an electrolytic tinning bath was found to have less effect on DAC grease than on other greases tried. Field tests showed DAC grease did not form deposits or wash out, and that the frequency of cleaning bearings and relubrication could safely be reduced by half.

The last application requires a grease that will perform under a combination of adverse conditions. DAC grease showed less consumption than previous greases and successfully lubricated laundry equipment in an environment that included heat, water, steam, and detergents in various combinations.

CONCLUSION

DAC-thickened grease possesses the broad range of characteristics required for multipurpose use. Because it combines good high-temperature properties with mechanical stability and water resistance, it can be used in more different applications than conventional multipurpose greases. This grease should help fill an expanding industrial need for improved lubricants.

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Determining Grease Consistency

(Continued from p. 26)

CONCLUSIONS

The automatic pressure viscometer described in this paper is felt to afford a relatively simple and rapid method for obtaining reproducible consistency data on various greases.

It is felt that the data are more complete and meaningful than is obtainable with the various single-point and single-pass capillary devices in popular use.

In addition to supplying comparative data for application purposes, the instrument seems capable of yielding information of a more fundamental nature concerning grease flow and the concept of the grease working.

Much more work will be required, particularly related to the thixotropic nature of grease before any general flow model for greases can be evolved.

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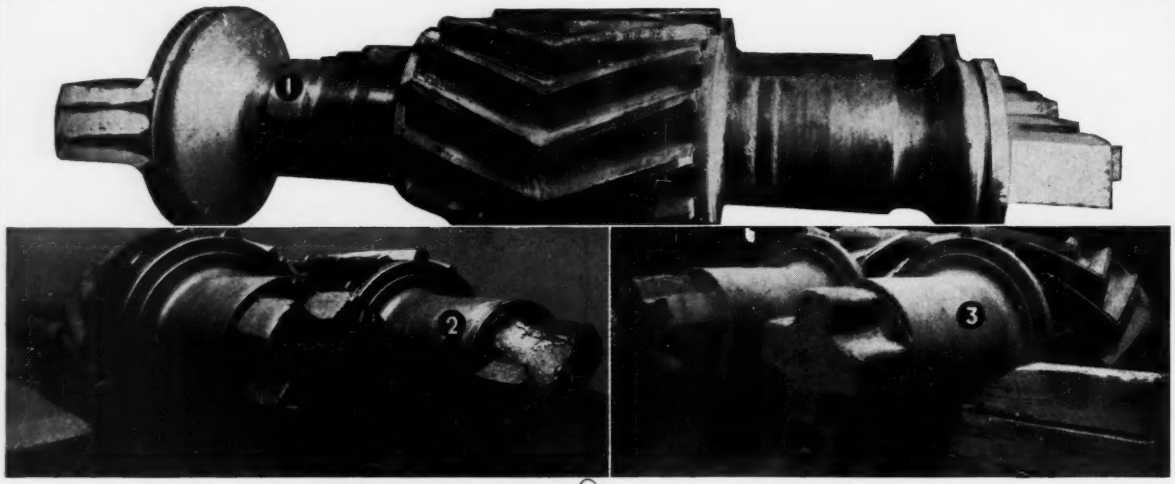

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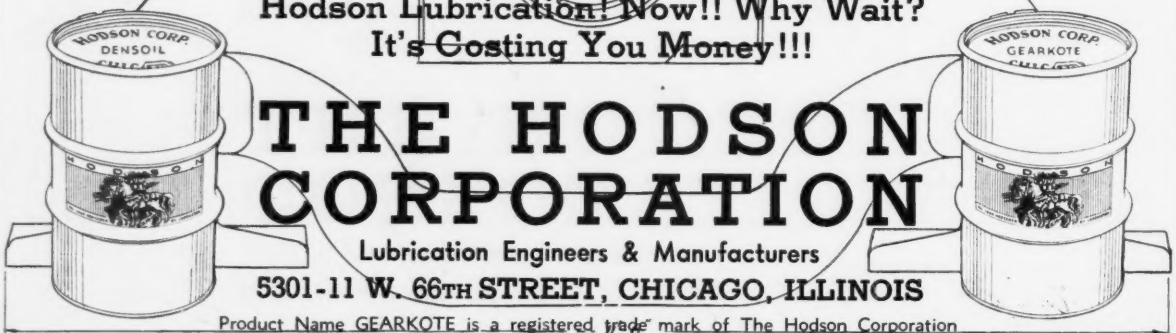

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